PSYCHOLOGY BY EXPERIMENT

KLINE

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PSYCHOLOGY BY EXPERIMENT

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GINN AND COMPANY
BOSTON · NEW YORK · CHICAGO · LONDON
ATLANTA · DALLAS · COLUMBUS · SAN FRANCISCO

PRINTED IN THE UNITED STATES OF AMERICA

627.6

The Athenæum Press
GINN AND COMPANY · PRO-
PRIETORS · BOSTON · U.S.A.

TO THE MEMORY OF

EDMUND CLARK SANFORD

"The stern were mild when thou wert by,
The flippant put himself to school
And heard thee, and the brazen fool
Was soften'd, and he knew not why."

PREFACE

This text is written with the conviction that psychology can best be approached under experimental conditions afforded by a laboratory equipped and set apart for such purposes. This position should hardly need emphasis, and will readily be admitted by all psychologists, yet there are very few such introductory laboratory courses. It appears, however, that psychology has made notable achievements and has justified its right to be classed as a science only as it has adopted the methods and procedure of the experimental sciences. It would seem, then, that the methods and technique used in discovering the laws of psychology should, when properly adapted, be most serviceable for teaching them. Moreover, psychology now has its own methods, technique, and apparatus, which have become so manifold, so simplified, and so standardized that it has for some time been possible to assemble, organize, and adapt a course of elementary experiments adequate for an introductory study of mind.

The present laboratory manual has been planned and arranged with the belief that while students are learning the fundamental laws of the science they should have ample opportunity to observe the continuity in its development, that such a course is not only logical and practicable, but is as necessary to understanding the science as are similar courses in chemistry, biology, and physics in their respective fields. It is based upon many years of experience, in which we have carefully tried out the experiments given. Naturally not all the experiments given here could be used in a circumscribed introductory course, but the number has purposely been made large so that selection may be possible.

The student is directed and encouraged to refer to the sources and to check his own work with the results of the pioneers and founders of the science. To this end we have freely drawn from

many sources, to which due reference is made in every instance. The carefully prepared texts and papers of E. B. Titchener have frequently served as models. The pioneer work of the late Edmund C. Sanford pointed the way in preparing laboratory exercises in sensation and perception. In common with present students of mind we are immeasurably indebted to the earliest teacher of one of us, William James. In this group of scientists whose teachings and writings have very materially aided us we desire to include Professor Knight Dunlap.

We are very grateful to Professor Donald A. Laird for reading the first draft of the manuscript and for making fruitful suggestions, to President Henry T. Moore for his advice and helpful comments upon several chapters, and to the authors here named for kindly permission to quote from their writings and to adapt certain of their experiments: Max F. Meyer, W. B. Pillsbury, Daniel Starch, E. L. Thorndike, E. B. Titchener, Lightner Witmer, and Margaret Floy Washburn. To our publishers, Ginn and Company, we are greatly indebted for suggestions adding to the usefulness of the book as a laboratory manual. The publishers who have kindly granted us permission to use quotations or modify and adapt certain experiments to harmonize with the plan of the text are R. G. Adams & Company, The Century Company, Harcourt, Brace and Company, Harper & Brothers, Houghton Mifflin Company, Henry Holt and Company, Alfred A. Knopf, Inc., The Macmillan Company, The C. V. Mosby Company, Psychological Review Company, Warwick and York, Inc., University Tutorial Press, Ltd., and The Williams and Wilkins Company. In each of such cases credit is given in the body of the text or in a footnote.

It is a pleasure to acknowledge the service and coöperation of Elizabeth A. Moshier, Department of Fine Arts, Skidmore College, and of H. B. Settle, photographer, in preparing most of the figures and also of C. H. Stoelting Company for permission to use photographs of their instruments.

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CHAPTER I

INTRODUCTION

The student of a science should become familiar at the outset with the assumptions, general premises, and types of reasoning involved in its investigations and in the formulation of its laws and principles. Such considerations need be neither pretentious nor complex, but should be sufficient to make clear the foundations, the scope, and the limitations of the science in question.

The aim of science in general is to discover and classify facts — facts about objects, facts about processes, facts about relations, and facts about conditions — in order to detect their sequence and causal connections. This aim rests on the assumption that nature is uniform in her operations, meaning by this that from a given set of conditions a predictable group of facts will occur. The key, then, to the facts of a science is to be found in the interplay between the phenomena, or the objects or the forces being studied, and the governing conditions. The conditions may be wholly or partly controlled or, in a few sciences like astronomy and meteorology, entirely uncontrolled. Wherever the conditions are wholly or partly controllable, it is possible to produce the same facts or occurrences at pleasure, thereby contributing immensely to the development of the sciences and facilitating the teaching art.

It is generally agreed that experimentation consists in the operations involved in controlling the conditions and in the observations made on the interaction between conditions and the processes or things being investigated. Such experimentation is usually first encountered in the laboratories of chemistry, physics, and biology. A simple example of the sort may be

seen in the botanist's control of conditions so as to bring out in bold relief the responses of roots and stems of developing seedlings to the stimulus of gravity. He does this by placing the roots of the seedlings in a constantly changing position, so that the stimulating influence of gravity is neutralized and does not act for a long enough time in one direction upon the sense organ in the root tip to accumulate a sufficient amount of excitation from the stimulus. The seedlings are pinned in various positions upon an upright, slowly revolving wheel and kept moist by dripping water. Under these conditions the roots and stems will continue to elongate in the same direction in which they are placed. Such an experiment shows the direct relation between the control of conditions and the sequence of facts essential to an explanation of the behavior of roots and stems under the influence of gravity. Knowing the invariable behavior of roots and stems under given conditions, the botanist expresses the fact in a general statement, or law, which forms the ultimate object of his quest. The fact that the conditions of an experiment may be controlled and varied furnishes a means by which a law may be confirmed, modified, or completely refuted.

The facts of psychology rest upon the same universal assumptions as those of the other sciences with respect to the uniformity and regularity of nature, and as a consequence the psychologist makes the special deduction that uniform psychophysical behavior occurs under similar conditions. The purpose of a psychological experiment is to devise and to control the conditions governing psychophysical responses and from the nature and relationships perceived in the latter to infer the laws of human behavior. Such is even the empirical practice of everyday life: one predicts the usual responses to the bite of a mosquito, to a clap of thunder, to a hearty laugh. In fact, the possibility of the science of psychology rests on the assumption that human behavior is explainable, controllable, and predictable.

It is highly desirable that the student early become imbued with the ideal that he is in search of laws of human behavior and that these laws, when arranged in proper order, in their totality constitute the science of psychology.

Human behavior involves four interrelated factors: (1) conditions including stimuli, (2) mechanisms and powers, (3) responses, and (4) results, or effects. *Conditions* (the word is used here generically) include all those of a specific character, as physical surroundings, social relations, problems (conceived as difficulties, obstacles, and tasks to be changed into simpler terms and forms for thinking about or acting upon), and also *stimuli*, as ether vibrations, radiant energy, and chemical substances. *Mechanisms* and *powers* are the means for making responses and include sense organs and nervous, muscular, glandular, and vascular tissues organized into functional structures operating as related parts of a psychophysical individual. *Responses* consist of the changes and actions, overt and implicit, set up in the organism by either stimulus, conditions, or problems, or any two or all three combined acting upon the individual. The *results*, or *effects*, of a psychophysical response are of two types: (1) effects produced in the individual by virtue of the response; (2) those produced on objects and processes. Upon the first type depend all habit formation, all feeling, all learning and knowledge, and upon the second all art, industry, and the like. This text seeks to emphasize each of the four factors in due proportion, ranking the second — mechanisms and powers — as the chief object of psychology, and the third — responses — as a revelation of the second. Of course the anatomy and physiology of man as related to psychology receive no formal consideration here. The student is referred to standard works on physiological psychology for such study.

Conditions and stimuli are considered only as far as they aid in the explanation of the responses and their effects. But it must be observed that there are many conditions to which man responds that are not as yet amenable to experimental procedure of an exact sort. The conditions provoking complex social processes, graver emotions, and strong passions must still be studied under chance conditions. Here the student of human behavior meets one of the limitations of the science and must perforce rely on fortuitous observations and upon analogies furnished by the study of lower animals.

Perhaps no part of a student's formal school work makes a more direct and persistent challenge to his mental integrity, his industry and habits of work, his nobility of purpose and sense of honor than the requirements inherent in laboratory conditions and methods of learning. But these very conditions and methods may produce malingering responses. Self-deception, easy satisfaction, and loose thinking may develop. Not only to avert such pitfalls and initial difficulties but far more to cultivate systematic methods and habits in experimental observation, a detailed account is given below for performing an experiment and for reporting and interpreting the results thereof.

THE EXPERIMENT

Meaning. In general an experiment is a critical observation made under standard conditions. In particular a psychological experiment consists of critical observations made under standard conditions on the reactions of an individual or of a group to a prearranged set of conditions. The character of the conditions may be of many kinds, and in all cases must be susceptible to control in whole or in part and capable of being repeated; they may be very simple or very complex. And in any and all cases the validity of the results will depend upon a strict adherence to the methods and conditions.

Purpose. The purpose of an experiment, like directions to a place, needs to be understood to perform a guiding function; its title may or may not indicate the purpose, and in the latter case the purpose must be explicitly stated. It is often helpful to re-read the procedure, results, and conclusions of preceding experiments, if related to the problem in question, to clarify the purpose. Before beginning work on an extended experiment, representative texts should be consulted and supplemented by discussion, and in any event an experiment should not be attempted until its object is understood.

Material. A detailed statement of the material should always be given, and if a description of apparatus is necessary, it should be so made as to enable others to perform the experiment with

similar means. If the apparatus is more or less complex, or consists of several pieces, it should be represented by a drawing duly labeled; it should be borne in mind that an unlabeled drawing has no value whatever in scientific work. A verbal description of even a simple apparatus is a valuable exercise.

Procedure. Usually the text will give the essentials of the procedure, but local conditions and other features may necessitate more or less of a departure. The procedure may be of three kinds: In one only the subject's part in the experiment is considered. For example, the subject is alone, without apparatus, and wishes to study the type and content of his memory images; he tries to recall in order the first five presidents of the United States; he observes his efforts to get the imagery, and notes the quality and content of the imagery as it appears. The student is here both subject and experimenter. The second kind of procedure usually requires a description of the apparatus and how to use it. For example, the student wishes to demonstrate for himself the effect that converging the eyes on a near object has on the appearance of a distant one in the same line of sight and records the procedure after this fashion: "I used for an apparatus a pen and a pencil; the former was held about 20 centimeters and the latter 40 centimeters from the eyes. I then looked fixedly at the point of the pen, and while the eyes were thus converged, I could observe out of their corners, as it were, two pencils, etc." A third kind of procedure takes into account a second person, the experimenter. In such cases the record states what the experimenter should do in conducting the experiment, how to use the apparatus, when and how to give signals and make records.

Results. The results of a psychological experiment fall into one of two classes of facts, depending upon whether they are reported by the subject or by the experimenter. Facts observed and reported by the experimenter (E) are termed *experimenter's facts*, or E's report, and those observed and reported by the subject (S) the *subject's facts*, or S's report. A "wry face" made by a subject tasting a bitter substance and observed and

reported by an experimenter illustrates the former type of fact; and the bitter quality of the substance as experienced by the taster is an example of the latter type, and when the fact is thus observed and reported by the subject it becomes available for scientific use.

Obviously experiments made upon animals, children, illiterate folk, and the mentally defective yield facts observed and reported only by an experimenter.

The two orders of facts as they usually occur in laboratory work are here illustrated by a report of an actual experiment. A subject was required to memorize a nine-figure square of Arabic and Roman forms arranged thus on cardboard:

5	L	V
IX	7	II
V	2	VII

The card was exposed to the subject for four seconds, after which he repeated the alphabet for six seconds, and then reproduced as many of the characters as possible. The characters as written are given here and form the experimenter's facts, or E's report, of the results:

9	L	V
X	7	
2	III	

Four were correct, one of which is misplaced, three wrong, and two omitted. The subject at once recorded the facts as observed by him as follows: "The figures were read as separate units and were not combined into a three-place number as 555, top line. The two upper lines were repeated silently (speech motor) and the entire group visualized; repeating the alphabet broke up my speech motor memory; the Arabic figures appeared in auditory imagery, the Roman in visual." Observe how these two groups of facts check and supplement each other: E's report gives both the quality and quantity of the reproduction, showing errors of which the subject was unaware, while S's report presents information of which E's gives no indication whatever.

In actual practice the purpose of an experiment, as well as the kind, determines the relative amount of emphasis to be given the respective types of facts. If one wishes to determine the extent of a space illusion or the rate at which S forgets nonsense syllables, E's facts may entirely suffice, but if one wishes to know the nature of S's after-images, or feeling response to a color, or æsthetic response to a geometrical form, or to know whether or not hunger sensations are present when the muscles of the stomach contract, then S's report is quite necessary.

These two classes of facts embody the raw results of an experiment, and to make their meaning obvious they must be arranged in form suitable for ready inspection and critical comparison. For this purpose the art of constructing tables, drawing curves and graphs, and of analyzing S's reports must be applied. Approved methods for these purposes will be given as required with the experiments in the text.

The facts, however arranged and expressed, usually require further consideration before the purpose of the experiment is completely realized. Written reports, tables, graphs, etc. call for description and analysis. The results, whether from an individual or from a group, should be compared with those of similar experiments embodied in standard sources, that both the verification and the connection of the student's work may be checked with what has become relatively permanent in the science. This is one of the purposes of assigned reading.

The ability to discuss and interpret facts develops by thoughtful practice and with a full recognition of the importance of interpreting results. The importance of this aspect of reporting an experiment requires repeated emphasis.

General statement, or inference. A report of an experiment is not complete, as shown by the report above, until a general statement, or inference, is made, based upon a discussion of the facts and upon the reading of standard works. In some cases it will be necessary to perform a related series of experiments before drawing an inference. In any case the general contents in the inference are suggested by the purpose of the experiment.

It will be advantageous, in the long run, to form the habit of allowing the *first* draft of a report to be the *best* as well as the *last.* The habit of rewriting results leads to inaccuracies in the first draft. The student of experimental sciences soon realizes that a large part of his attention must be given to the prevention and elimination of error. Cautions, directions, suggestions, and prescribed forms are largely for the sake of preventing error, and in the study of experimental psychology they apply with special force for the reason that the science is beset by prolific sources of error. The directions for conducting and reporting an experiment are here summarized in the form of an outline that may be used in recording laboratory exercises.

I. Number and purpose of the experiment
II. Material (apparatus drawn and duly labeled)
III. Procedure (usually given in some detail)
IV. Results
   1. Subject's report on his own experiences
   2. Experimenter's report (observations, tables, graphs, etc.)
   3. Discussion and assigned reading
V. General statement or inference

To illustrate the importance of discussion, as well as to exemplify the practical use of the points just described, there is given below a copy of a report of an experiment done by a student taking an introductory course in which two hours of laboratory work were required regularly.

A STUDY OF DIVIDED ATTENTION[1]

Material. Odd numbers from 1 on, letters of the alphabet, pen and paper, stop watch.

Procedure. A. The instructor gives the signal to begin and all S's count softly by odd numbers for one minute. When time is called E writes down the last number.

B. All students write in order the small letters of the alphabet as rapidly as possible, writing each one separately and beginning at *a* again immediately on finishing *z*, writing the alphabet as many times as may be during one minute.

[1] This problem was suggested by Experiment VII in *An Introduction to Experimental Psychology in relation to Education*, by C. W. Valentine.

C. S performs as well as she can both operations at once, counting the odd numbers aloud and at the same time writing the alphabet, continuing both operations for one minute, while E observes and writes down the last number counted.

Results. Subject's report. Is there a consciousness of performing two operations at once? Yes. I was conscious of having to keep track of just where I stopped in each series. The idea that I had to do this and that I was to do it as fast as possible caused great confusion and checked the speed.

In *C* I wrote one letter of the alphabet as I said each number.

Experimenter's report. This is shown in tabular form.

RESULTS IN DIVIDED ATTENTION

	NUMBER OF NUMBERS	NUMBER OF LETTERS
Undivided attention (*A* and *B*) . . .	87	106
Divided attention (*C*)	41	41
Per cents in *C*	47	38

Discussion of results. If both operations had been performed at once, each independently, 87 numbers would have been recorded in *C*, 106 letters would have been written, and 100 per cent in efficiency would have been gained.

If the two operations had interfered with each other, and the attention had been proportionately divided, so that no two items of the operations had been performed simultaneously, there would have been 43 or 44 numbers and 53 letters recorded in *C*, or just 50 per cent of *A* and of *B*. In my results I did not reach the 50 per cent mark, which shows that the two operations interfered with one another to such an extent that I lost in efficiency 15 per cent, not even being able to attain equal efficiency. My results in the *C* part were only 47 per cent and 38 per cent of *A* and *B* respectively. If I had found a gain in both cases, it would have proved that I had successfully performed two operations at once, but *not* that I had attended to two things at once. Attention can be given to only one thing at a time, and so in this experiment it would have to change back and forth between the numbers and letters. On the other hand, the performance of two operations at once is shown by the fact that I could say the number at the same time that I wrote the letter. Another explanation might be that I had taken the numbers for a

certain time and then switched back to the alphabet for a while and then back to the numbers. A plan could have been worked out by means of which efficiency could have been gained, as I found out by trying outside the laboratory.

Individual characteristics that favor the performance of two tasks simultaneously are: the power of extremely quick thought; the lack of tendency to get confused in a task, in other words, clear-headedness or cool-headedness; the ability to retain two ideas or trains of thought in the mind without confusing them; and absolute coördination of hand and brain.

The apparent divided attention of musicians and jugglers may be accounted for by the fact that their playing or juggling has become habitual. Pillsbury says: "Careful investigation has shown that two things can be done at once only if one has become so habitual as to require no attention."[1]

In the case of a musician, if he is reading music a certain note on the page produces an absolutely automatic response. If he is playing from memory it is easier yet; his hands just fall into the accustomed positions, and he is able to carry on a conversation as he plays. With the juggler, too, his hands fly to positions automatically, and he can devote his attention to something else.

There are innumerable instances of attention being apparently given to more than one operation at a time. A person may manicure his nails and trim and polish them carefully and yet be talking all the time, because the manicuring has become habitual. Or one may drive an automobile, including shifting of gears and all other needed operations, and carry on at the same time a conversation. Also the artist can paint or draw as he is talking.

To sum up, then: If the results in each part of *C* had been 50 per cent of *A* and *B*, there would have been no gain or loss in efficiency. If they had been over 50 per cent, efficiency would have been gained, and if under 50 per cent, efficiency would have been lost. As the majority of the class lost rather than gained, it may be inferred that except in a few cases efficiency is lost by trying to do two things at once, unless one becomes habitual. "If both require full attention, only one at a time can be carried on to advantage."[1]

Inference. Two operations may be *performed* at once, but attention may be given to only one at a time. Two operations may rarely be simultaneously performed to advantage unless one has become so habitual as to require practically no attention.

[1] W. B. Pillsbury, *Essentials of Psychology*, pp. 124–125.

GENERAL ARRANGEMENT

The experiments are grouped into chapters in accordance with the generally accepted major problems of the science. At the beginning of each chapter are a few quotations taken from original sources, arranged roughly in historical sequence, and in some instances reflecting the progress of the subject of the chapter. The outline following the quotations is designed (1) to suggest reading beyond the problems set for laboratory work, (2) to present a more extended and coherent view of the subject of the chapter, and (3) to furnish a type-plan from which new outlines may be constructed.

The outline is followed by a brief introduction, the aim of which is to give some insight into the nature and office of the responses in human life, to orient the student with reference to the laboratory exercises, and to guide him in performing the experiments and in doing the assigned reading. The questions appearing at the end of nearly every experiment are intended to develop its significance, to aid in stating a conclusion based upon discovered facts, and to require a search for practical applications; and those at the end of each chapter are intended to develop the practical side of psychology as well as to aid in reviewing the chapter.

DIRECTIONS FOR USING BIBLIOGRAPHY

References to the bibliography are made in two places: (1) in the brief introduction to each chapter of experiments, and (2) at the end of each experiment.

The authors' names appear in the bibliography in alphabetical order and are numbered, as is the custom; they are referred to throughout the book by number and pages. For example, at the end of Experiment 89 in the chapter on "Memory and Imagination" a reference appears thus: "27: 102–104." An inspection of the list of names at the end of this chapter shows that reference is made to a paper called "A Study in Incidental Memory," written by G. C. Meyers and published in the *Archives of Psychology*.

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CHAPTER II

THE INDIVIDUAL AND THE EXPERIMENT

The individual. One of the possible pitfalls of experimental psychology consists in the danger of gaining unrelated and detached views of man's mental life. Laws and principles so industriously formulated from facts derived from experimentation on the *same* object — man — sometimes do not hang together or become united into a coherent system of knowledge. Another ever-present danger is seen in a tendency to shift attention from the object of study — psychological organism — to the apparatus, the methods, the stimuli, and the conditions; ends and essentials are supplanted by means and accessories. Although these pitfalls and dangers are not peculiar to psychology, they are, perhaps, most threatening to a successful study of that science.

Obviously a working knowledge of the source, nature, and object of psychology and of the meaning, purpose, and results of experimentation should prepare us to interpret and organize the observed facts into a coherent system of laws, and to recognize and hold fast the distinction between ends and means and the essentials and accessories in experimentation.

Source of psychology. We have already observed that human behavior involves four interrelated factors: (1) stimuli, (2) mechanisms and powers, (3) responses, (4) results, or effects. The relations between two of these four — stimuli (including conditions) and mechanisms and powers — reveal the source of the subject matter of psychology. If environment is substituted for stimuli and conditions, and the individual for mechanisms and powers, then, following the lead of Professor Warren (**6**: 2), one may say that the subject matter of psychology originates out of the interactions between the individual and his environment.

Nature of subject matter. The character of the individual's participation in the interaction is governed by the coördination or better integration of receptors, neural conductors, and motor and glandular effectors, — all structurally discrete mechanisms, but functioning as a single organism. The statement is often made by psychologists that the individual responds as a "unitary whole," or that the response is "in the interest of the individual." There is some vagueness and seeming exaggeration in such an assertion. Let us see.

My finger is throbbing, having been caught by a window sash. The throbbing is a physiological process and is explained by the laws of physiology; it is localized and involves a limited number of other parts. *I* seek a remedy; all constituent parts of myself are drafted into the enterprise; each part is coördinated and working with every other part in search of relief, attending to perceived and remembered objects that may serve my purpose, selecting and rejecting material, measuring, cutting, fitting, tying.

My hair needs trimming. The need was created by processes of growth which are explained by biology. I go to a barber shop. Muscles involved in standing, walking, and seeing are brought into play; objects, distances, and directions are perceived on the way to the shop; perhaps previous visits are recalled, verbal-social ideas expressed.

The respective strength of each of the several activities in the two cases was graduated with reference to the contribution of each to the whole task; their rate, accuracy, and steadiness were regulated for the whole individual, not for any part; mutual reënforcing, supplementing, and checking were done for purposes conceived by and for the individual. These two examples illustrate three points important for scientific psychology:

1. Responses that are duly coördinated, controlled, and steered toward accomplishing definite purposes function as a unitary whole.

2. Such responses are in the interest of the individual and not of a mere part. The "throbbing" and the "long hair" were

affecting an individual adversely, and called for a remedy and a correction for the sake of self. The solicitude in both cases is not for the throbbing or the long hair, but for self, the individual affected by them.

3. Responses made for and involving the whole organism are strictly subject matter for psychology. No other science attempts to, or can, describe and explain such activities. Professor Pillsbury observes that psychology "deals in general with the acts of the organism as a whole, rather than of the parts, and it considers the acts of the organism only in so far as they are not explained by physiology and other distinctly biological sciences" (**4**: 8).

Those who would limit the subject matter of psychology to movements, to glandular and visceral actions, are called behaviorists, — a special use of that term. The instances just cited above contain, however, such words as "attending," "perceiving," "remembering," "selecting," and to these should be added "recognizing," "feeling," "ideating," "reasoning," etc., names for different phases of consciousness. These processes, taken in their totality, compose our mental life, or mind so called. It is important for students of psychology, and especially for those approaching the subject by means of experimentation, to grasp the conception that these several phases of consciousness operate by and for the entire individual, — similarly to the motor activities described above. An illustration from learning to play tennis must suffice. One gives rapid mobile observation (attention) to a "served ball" (perception), and on account of the speed and angle at which it approaches the back-line refrains from hitting it (memory, comparison, judgment, volition). As the ball passes over the line, satisfaction (feeling) arises for having scored a point and for making a correct inference in so new a situation. Encouraged (feeling-elated mood) by this gain, one resolves (attitude and volition) to put more effort into the game. As in case of the motor reactions, so here the mental processes reënforce, supplement, and check each other, some occurring in an apparently cause-and-effect relation and serving the individual as a whole. It turns out that both

conscious processes and movements function as a unitary whole for individual ends and purposes; this is tantamount to saying that conscious experience and movements not only constitute the subject matter of psychology but that they are definitely related and in such a manner that the activities of one may be inferred from those of the other. And that is what occurs in the common experiences of daily life. If, for example, I am suffering from dizziness and blurred vision while reading, I will consider whether a lurking sinus trouble, overeating, too strenuous exercise, or some such bodily cause may not have so affected the visual centers of the brain as to produce dizziness and imperfect vision. From purely psychological grounds I infer that there is a disturbance in the body functions. And I may then try to arrive by physiological considerations at a probable explanation of the mental disturbance. Or again I may look at the thermometer in my study and be surprised to find it registering a temperature far below the point of comfort and I recall having shut the heat off earlier in the evening and forgot to turn it on. I straightway explain my forgetfulness by the unusual interest in the reading, — a psychological explanation for prolonged bodily activity. (**3**:33)

All conscious experience requires bodily action, but the reverse does not appear to be true. If bodily action is to have psychological significance, its dependent mechanisms must have been integrated to a degree in which their functions produce conscious experience of one sort or another.

Object of psychology. Two questions are involved here, growing out of the present stage of scientific development of psychology: (1) What is the object of psychology as a pure science? (2) What is its object as an applied science? Answers to the first must be made in terms of what is to be scientifically done with the subject matter. Hence facts about movements must be discovered and explained; a study must be made of their origin and integration into movement systems, of their correlation with the laws of nervous physiology and with those of conscious experience. Facts must be gathered from genetic and experimental psychology as well. Examples of contributions

from the latter field are found in studies on reaction time and in the development of a hierarchy of movements such as occur in learning to write or to play the piano. Likewise facts of the emergence and development of conscious processes must be discovered and explained; their relations to each other, as perception to imagery and to ideas, feeling to attention, memory, learning, etc. Then, too, the dependence of consciousness upon bodily reactions, so marked in attention and emotions, presents a wide and diversified field for scientific study.

The object of applied psychology coincides with that of other natural sciences in that it aims to predict and to control. Predicting how one will act and will achieve in any given situation based upon common sense is an everyday occurrence. The only justification for psychology to undertake such work rests on the assumption that it can do so with greater certainty and thereby avoid costly mistakes. As in general psychology, so in applied psychology the entire individual in relation to his environment must be studied. Interviewing applicants for work may serve for an illustration: applied psychology not only points out the many pitfalls but furnishes scientific grounds upon which the interview should proceed, and suggests directions by which the results may be used.

Summing up briefly the relations of the individual to psychology, we observe that those reactions which function in the interest of the whole organism form the subject matter of the science; that the nature of these reactions consists of conscious processes dependent upon bodily activities, and that the object of psychology is (1) to discover and formulate the laws of conscious processes in their relations (*a*) to each other and (*b*) bodily reactions; (2) to discover and state the laws of movements in relation (*a*) to each other and (*b*) to conscious experience; and (3) to apply the laws thus discovered to the art of predicting, guiding, and controlling human behavior.

The experiment. Psychology has fully evolved descriptive, explanatory, and predictive stages; hence it has attained its majority, the adult stage of a science. We have already observed that the technique and methods used in discovering the laws

and principles of psychology should, when properly adapted, prove most serviceable in teaching the science. To experimentation as already defined very largely belongs the credit for the present status of psychology. It is therefore important that the student should have an adequate conception of the use of experimentation as a means of learning the science and that he should cultivate an attitude of critical earnestness toward its methods and technique.

In the first chapter attention was given to ways and means for conducting, recording, and interpreting the results of an experiment. Additional suggestions and comments are submitted with a view of aiding the student to become properly oriented in the work, to avoid waste, and to conserve time and effort.

1. A laboratory experiment is not a mental test. It is not concerned in determining the character of a reaction in terms of standard achievement, however derived.

2. An experiment is not intended to furnish logical and mathematical proofs; it seeks rather to secure similarities and uniformities in reactions made by different individuals under the same internal and external conditions and to the same stimuli.

3. Laboratory experiments arranged for students have one or more of the following purposes: to give practice in setting up and in using apparatus; to furnish opportunity for working in an orderly manner, accurately and rapidly (a laboratory dawdler is out of place); to demonstrate an established law (usually the law is unknown to the student, and hence for him it is a discovery); to discover new facts that may tend to support or refute a current theory (such achievements are, of course, rare, but when they do happen, new zeal and set purposes follow).

4. The failure of an experiment may prove a success in disguise in that it may induce more caution, arouse closer observation, and incite greater determination.

5. The object of an experiment should never become secondary to apparatus and conditions. This principle need not be confused with work devoted to devising and trying out appara-

tus or to testing and standardizing conditions. All such work should be regarded as devising and perfecting ways and means for experimentation.

6. Do not alter the conditions and directions. Any change in the aim of an experiment usually occurs from misunderstanding, and at times changes in directions and conditions happen from the same cause. There are other reasons why conditions are changed that call for the student's attention: (1) carelessness, indifference, or a mind prepossessed with other interests for the time being (such attitudes are handicaps in any work but are absolutely fatal to success in a psychological laboratory); (2) a desire to *get through* and to *have done with it*; (3) an endeavor to be original and spontaneous (neither science nor art can afford to lose original ideas, but before changing the conditions to accommodate such ideas, *see the instructor*).

7. It is important to realize in the beginning that experimentation is the surest and in the long run the speediest method for learning psychology *as a science*. This view is generally accepted in teaching and in learning other natural sciences. One can acquire considerable information about botany or zoölogy or physics or psychology or the like without experimentation, but such knowledge is empirical, unorganized, one-sided, and too often misleading despite the watchful care of common sense.

The value of experimentation in acquiring a living and working knowledge of science and in permanently removing the veil from many of the secrets of nature becomes evident by comparing the relative permanency of the forms in which science exists. These forms are as follows: First, science as knowledge in the minds of people has a precarious, evanescent, and transient kind of existence, and were that suddenly to become its only dwelling-place, it would soon revert to pseudo-science, legend, and folklore. Second, science as applied to industrial processes, to the construction of machines, engines, and structures, is concrete, palpable, and observable, and is considerably more stable than in the form of individual knowledge. Use and time are the great destroyers of this form. Third, science expressed in symbols, of whatever sort, and in divers

materials, usually addressed to the eye, is comparatively permanent. The accumulated science of the ages is in such forms. It is recorded, with other forms of knowledge, on stone, pottery, metal, papyrus, and by far the greater and more important parts are recorded on written and printed pages. These symbolic forms contain descriptions and explanations of scientific discoveries and records of ways and means for devising and constructing apparatus, — records of marked self-denial, of failures and successes in experimentation. Here are recorded hypotheses and theories and the facts discovered to prove or to refute them, accounts of applying old formulas and of deriving and testing new ones, accounts of discussions, arguments for and against the validity of a given experiment, etc. These records form the history of science and are for the most part descriptions of experimentation — the only way by which science has made permanent progress and the better way by which it may be learned. But in all cases experimentation has been a means to an end, a wonderful tool by which man has erected the enduring structure of scientific knowledge.

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CHAPTER III

MOVEMENT

1. The term "movement" is here used in a technical sense, and means *any set of coördinated muscular action.* — CHARLES MERCIER, *The Nervous System and the Mind,* p. 83

2. Let us use the term *movement system* to indicate *a combination of movements so linked together that the stimulus furnished by the actual performance of certain movements is required to bring about the other movements.* — MARGARET F. WASHBURN, *Movement and Mental Imagery,* p. 10

3. A movement that has mental . . . antecedents and mental concomitants is termed an *action*; and the problem which "doing things" sets to psychology is that of tracing out the various sets of processes which can serve as the conscious condition of the various forms of action. — E. B. TITCHENER, *A Primer of Psychology,* p. 162

4. Three elements, then, combine in the initiation and guidance of a movement. (1) The general idea or intention to move. This is found in the thought of the movement or of the end to be attained. (2) The remote sensations from eye or ear. (3) The resident sensations from the moving member itself. These resident and remote sensations control the *direction* and force of the movements. — W. B. PILLSBURY, *Essentials of Psychology,* p. 301

TOPICAL OUTLINE

General Classes of Reactions
- *A.* Reflex (simple, inborn): blinking
- *B.* Movement (simple and complicated, acquired, explicit): writing
- *C.* Ideational (acquired, implicit): thinking
- *D.* Affective (acquired and inborn, visceral): anger

Forms of Reactions as to Kind of Mechanism
- *A.* Glandular: perspiring, salivating, secreting, for example, adrenalin
- *B.* Vascular: blushing, paling, pulsating
- *C.* Muscular: pounding, running, jumping
  - I. Types of muscular reaction
    - 1. As to origin
      - *a.* Innate: reflexes, automatisms
      - *b.* Acquired: signaling, speaking, reading
    - 2. As to degrees of consciousness
      - *a.* Not-conscious: pupillary reflex, dilation of alæ
      - *b.* Marginal: sensori-motor and ideo-motor reactions
      - *c.* Focal: threading a needle, drawing from memory

3. As to self-controlled reaction
    a. Involuntary: sneezing, patellar reflex
    b. Voluntary: checking impulse to cough, reading a difficult passage

II. Voluntary or self-controlled reactions
1. Conditions: two or more ways of reacting
2. Motives (composition of)
    a. Idea of one's own act
    b. Idea of result of action
    c. Perception of object
    d. Feeling-tone
3. Central (mental) reactions between idea of action and its overt execution: deliberation (means of), hesitation (cause of), decision (feeling of relief)
4. Factors controlling overt reaction
    a. Resident and remote kinæsthetic sensations
    b. Acquired inhibiting mechanisms
5. Abnormal movement reaction
    a. Speech defects
    b. Alexia, agraphia
    c. Ataxia

Time Relation of Movement Reaction: Reaction Time

A. General problem: Determine the time required for a conscious reaction by measuring the interval from the presentation of a stimulus to the making of a prearranged response.

B. History of the subject
- I. The "personal equation": its history and correction
- II. Measuring the rate of a nervous impulse
- III. Use of electrical mechanisms for measuring reaction time
- IV. Use of the vernier for measuring reaction time

C. Classes of reaction time
- I. Simple, based upon the direction of attention
    1. Sensorial
    2. Motor
    3. Central
- II. Complex, based upon the intervention of one or more mental or implicit factors between the perception of the stimulus and the response
    1. Discriminative reaction
    2. Cognitive
    3. Choice reaction
    4. Associative reaction
        a. Free
        b. Partially or wholly constrained

D. Conditions affecting reaction time
- I. External determinants
    1. Quality, intensity, duration of stimulus
    2. Climatic conditions: atmospheric pressure, temperature
    3. Social and other distractions

II. Internal determinants
   1. Age and sex
   2. Practice, attitude, expectation
   3. Health, fatigue, drugs

INTRODUCTION

Description of terms. The experiments of this chapter contain several words, as "consciousness," "stimulus," "reaction," "movement," "reflex," "discrimination," etc., used in a technical sense and requiring at least working definitions.

1. The term "consciousness," because of its basal character in psychology, calls for first consideration. It is "the distinctive basal characteristic of mental life in actual process" (**5**: 22); it is awareness of oneself and the world about the self. This does not imply awareness of the entire self or of all the world present to self at any one moment, but only of such parts of each as conditions may require. At one moment one is conscious of cold hands, at the next of one's gloves in one's pocket; or again one stands in admiration before a beautiful painting apparently unmindful of self, when suddenly a slight aching forehead brings the self back to consciousness. The more manifest conditions and signs of consciousness are stimulus, responding mechanisms, and responses, but further acquaintance with its conditions shows that stimulus and response are merely the end terms of a series of conditions, the largest group of which is confined to the responding mechanism, the major part of which is the central nervous system. That consciousness operates in such conditions is generally accepted; just *how* it operates is as yet unknown, but the approach to the solution of the how belongs to the field of physiological psychology.

2. A stimulus (**21**: 22) may be regarded as any small force that releases a larger one. It has been likened to the blow of a hammer that explodes the powder of a cartridge. When limited to organic life, it means any force that arouses a resident power in the organism, and when applied to animals with a completely differentiated nervous system, it is the force that arouses an impulse in an afferent (incoming) nerve (**10**: 127–144).

Stimulus, in short, is a physical factor. Sunlight falling on the hand warms it. It is a silent, invisible force, but its cumulative effect is most pleasantly observed on a cold day. When sunlight falls upon a book it is reflected, and the book is visible. The sunlight stimulating the skin produces the sensation of warmth; stimulating the eye it produces the sensation qualities which, added to experience, tell us that the object is a book.

The usual way of starting a nerve impulse is by applying stimulus to a sense organ, by which it becomes transmuted into a nerve impulse.

A comparative study of the classifications of stimuli as given in introductory texts on psychology is advisable. (**5**: 42–47; **16**: 11–12)

3. A reaction of the simpler kind is a more or less quickened muscular action, glandular secretion, or vascular change due to the excitation of a nerve impulse by an efferent (outgoing) nerve. In a more complex sense it may be conceived as a set of psychophysical changes occurring in an organism during the process of adjustment to specific conditions (**5**: 186–189). The terms "response" and "expression" are synonyms for "reaction," although they may form only a part of a reaction. The kind, quality, and intensity, or amount, of reaction furnish the larger and more intricate problems of psychology.

4. Discrimination is among the earliest responses of infancy and is often regarded as an index to intelligence. It may be described as a reaction to a difference between compared stimuli. When no difference is sensed, the two stimuli, forces, objects, or whatever is being compared, are reacted to as similars.

5. A movement (**18**: 447–458) is any set of coördinated muscular actions accompanied by a variable degree of consciousness. The term "coördination," as used here, is well described by Mercier.

Hence it appears that for the due performance of every movement whatsoever there must be action of a plurality of muscles determined in a plurality of ways; that the forces, times and extents of the action of one set must bear a due proportion to the forces, times and

extents of the action of the other set. When muscular actions are thus combined in due proportion they are said to be *coördinated.* (**11**: 63–64)

Since a movement is a coördinated action of many muscles working toward an end, it implies the presence of consciousness in a functional rôle, as it is the only principle by which awareness of ends becomes known. On this account the term "movement," as used in the text, carries with it the idea of consciousness.

6. When a stimulus acting on a sense organ arouses some form of reaction by means of an afferent nerve, a neural center, and an efferent nerve, the entire process is termed a reflex; and the path thus formed for the transmission of the nervous force is called a reflex arc (**3**: 1 ff.). The nervous centers, or ganglia, of the more primitive reflex arcs redirect the nerve force, perhaps the simplest and first function of the nervous arc. But to the complex nervous systems of vertebrates two other functions are added: (1) facilitation of nerve impulses and (2) their inhibition. These several functions concern the psychologist only in so far as they are conceived as the physical correlates of conscious behavior. Among the correlations those of time have been the object of careful study, for it was assumed that "the time occupied by nervous events" was equivalent to the duration of the corresponding mental processes, so that the time measurements of the former determined, as it were, the temporal course of the latter.

Reaction time. This is reckoned from the time the stimulus is applied to a sense organ to the time of the response of the moving mechanism. Such an interval is termed *reaction time.* The psychologist describes reaction time as the interval between the application of a stimulus to the subject and his response to it in a prescribed manner (**7**: 1–56).

The starting-point for studying experimentally time relations of mental phenomena is made by determining the so-called simple reaction time. Reaction time is regarded as *simple* when a direct response is made to the stimulus (**17** : 117–125). The conditions require that the subject shall know beforehand the exact nature of the stimulus, its manner of application, and

the precise mode of response; for example, subject is to press a particular key of an instrument with the index finger at the appearance of a known red disk or on hearing a familiar click at a previously designated point. Another important condition requires that the subject shall be warned a second or two before the application of the stimulus. This may be done by the experimenter's signaling "Ready." These conditions are necessary for keeping the variations of the simple reaction time in a series within the narrow limits required for valid results. But even with foreknowledge of the stimulus and of the manner of response, with a preparatory signal, with freedom from distraction, with uniformity in the direction of the observer's attention, and with comfortable bodily position, the time will vary from one trial to another. On account of these variations some arithmetical computations must be made so that the results may be readily compared with those in standard texts.

Simple reaction time. The simple reaction time obtained under such conditions is found upon analysis to be composed of a number of coördinated processes working as a unitary whole; the separable physiological processes are supposed to coincide with the number of structural parts of the reflex arc. The processes are (1) transmuting the physical stimulus into a nerve impulse by the sense organ; (2) conducting the impulse to an appropriate sensory center of the cortex by an afferent nerve; (3) transforming the sensory impulse into a motor, or efferent, impulse; (4) conducting the motor impulse to a reactor; and (5) the response of the reactor. This last response constitutes the end of the physiological processes included within the measured reaction time, and at the same time it initiates an afferent impulse which, on reaching the cortical centers, gives rise to a sensation of movement, the so-called kinæsthetic sensation.

The mental phase of the reaction processes involves three distinguishable parts: (1) the ideas of responding and ideas of bodily adjustment reënforced by kinæsthetic sensations, which are excited by placing the sense organ in a favorable position for receiving the stimulus and by putting the body parts into proper

position for ready response; (2) the perception of the stimulus and its connection with the idea of response and the fiat of the will to respond; (3) the sensation of movement and usually a feeling-tone based upon the response. These three processes are sometimes designated as pre-reaction, reaction, and post-reaction, and, although they are separable in analysis, they form a continuous sequence of mental events operating as a unitary whole (**10**: 470–499).

Types of simple reaction. Simple reaction times vary in length according to the direction of the subject's attention in the pre-reaction period. If the attention is directed toward the apprehension of the stimulus, the time rate is termed sensory and is the slowest of the simple rates. If the attention is given to the making of the response, the time is called motor and is found to be the shortest. But if the attention vacillates indifferently between the idea of the stimulus and the idea of movement, the time is called central, and the time rate is between the sensory and the motor. These different types of reaction have been known since 1888. The results of some of the original investigations appear in the following table:

TABLE I. TIME OF THE TYPES OF SIMPLE REACTION[1]

OBSERVER	NATURE OF STIMULUS	SENSORY TIME (SECONDS)	MOTOR TIME (SECONDS)	CENTRAL TIME (SECONDS)
Lange	Visual	0.290	0.113	
Titchener	Visual	0.268	0.181	0.19–0.22
Münsterberg	Auditory	0.162	0.120	
Titchener	Auditory	0.233	0.120	0.14–0.19
Lange	Tactile	0.213	0.108	
Titchener	Tactile	0.210	0.110	0.12–0.18

Complex reactions. A second group of reactions is that in which one or more mental factors intervene between the perception of the stimulus and the motor response; or, in terms of conditions, the time here is the interval that elapses between

[1] This table is arranged from Titchener's *Experimental Psychology: Instructor's Manual, Qualitative*, p. 216, and from Breitwieser's "Attention and Movement in Reaction Time," *Archives of Psychology*, Vol. II (1911), p. 4.

the reception of a more or less known stimulus and the making of a movement more or less definitely prearranged.

Several types of complex reactions have been determined, such as discriminative, cognitive, choice, and associative.

1. The discriminative reaction is like the sensorial reaction of simple reactions, with the difference that two or more stimuli may be used and the subject responds after he has discriminated between the particular stimulus presented and the other possible stimuli; for example, the subject is told that he will be shown one of three bits of white cardboard cut, respectively, in the form of a triangle, a square, and a circle, and that he is to respond as soon as he discriminates the form presented.

2. The cognitive differs from the discriminative only in the use of a greater variety of stimuli; a dozen geometrical forms are used instead of three or four; even short familiar words may be used. In the discriminative type all the possible stimuli may be kept fairly well in mind, imaged in one pulse of the attention during the pre-reaction period, whereas in the cognitive such a task is impossible, so that when the particular stimulus appears it must be reknown, that is, cognized.

3. The conditions in choice reactions require the subject to make choice of his responses as well as to discriminate between stimuli. Two or more stimuli are each correlated either with a specific movement or with the absence of movement. The subject is told to respond with the right index finger at the exposure of a red disk and with the same finger of the left hand to a yellow disk, or to respond to a letter of the alphabet by naming it and not to respond if a digit is shown.

4. An adequate description of associative reactions (**8**: 218–269) necessitates an account of the laws of habit formation and those of association. Such an account is particularly essential in the application of the results of the associative reaction to a study of mental types, of abnormal complexes (**6**: 111–136), of the nature of concealed experience (**12**: 73–133), and especially for some of the laws of inhibition. The present description, however, is confined to experimental procedure; the problems of association are considered in a later chapter.

In the associative reaction the subject does not respond to the external stimulus at all, but to a central stimulus or an associative process, so called, — to the "idea" aroused by the perception of the stimulus (22: 9–23). The stimulus is usually a word seen or heard; it may be a figure or a familiar symbol. An associative reaction time, then, is the interval between the appearance of a symbol or word stimulus and the response, consisting of another word or symbol having some form of association with the first. We are continually building such associations from childhood on: connections between names and their objects, between things and their uses; between words, signs, symbols, and their respective meanings; between causes and their effects, conditions, and consequences; between numbers and their sums, products, differences, powers, and roots; between the names of countries and their capitals, products, industries, etc. (20: 4–98).

There are three forms of associative reactions, the first and simplest of which is the "free" association. Here the subject responds when the word has suggested anything from a mere fancy to a word bearing the subtlest relation to the stimulus word. In laboratory practice one begins with this type on account of its simplicity, but this simplicity has proved its strength in making ready and valuable contributions to both theoretical and practical psychology, and as a consequence it has received a larger share of attention. The second form is the "ambiguous," or partially constrained, association. This has been termed logical reaction by some authors. In this form the range of possible associations to the stimulus is limited. The subject may be shown the name of a class — for example, "bird" — and be required to respond with the name of a particular instance of the class — such as "robin" or "sparrow" — or he may be shown the name of the instance and be required to respond with the name of the class, or an adjective may be shown requiring a response by giving the corresponding substantive; for example, "gold" — "coin." The third form is the "constrained" association. Here the stimulus word, number, or symbol admits of only one correct response. The subject is

asked a question that admits of but a single answer. Thus he may be asked to give the word opposite in meaning to the stimulus word, to name the country where a poet lived, to name the author of a work, or he may be given a number and required to respond with the sum or product as affected by the stimulus number.

The discriminative and choice reactions tend with practice toward the sensorial reaction, within certain limits. The approach is most marked in the choice reactions, owing to the fact that each movement becomes associated with its particular stimulus in reflex fashion and thereby well-nigh eliminates the distinctively choice reactions. Both simple and complex types of reaction are typical of the larger portions of our common industrial and skillful activities as well as of many of the purposive movements of our everyday life. Colored lights, bells, horns, whistles, sudden sounds, and waving flags are used as stimuli, and opening and shutting throttles, turning electric currents off and on, pulling and pushing levers, turning cranks, gearing and ungearing machinery, are some of the responses. Again, letters, words, figures, symbols, "cold" shorthand, and oral dictation are stimuli, and writing, speaking, reading, and manipulating keys of the typewriter are the several responses. In plays and in games the signals made by the voice, by pistol shots, by whistles, and by flags are the usual forms of stimuli, and kicking, punting, throwing a ball, pulling an oar, and running a race are among the responses.

Evidently the study of the time relations of mental phenomena under experimental conditions provides a means for making a critical and controlled study of many common volitional processes.

REACTION TIME

The purpose of the reaction-time experiments is to study the time factors involved in immediate and predetermined responses to known stimuli, such as response to a gymnasium or military command, to colored lights in traffic, etc.

The conditions, processes, and mental phases as given in the Introduction are to be brought out in the discussions of the several experiments, and the analysis should show what differentiates simple from complex processes and the characteristics of each type of simple and complex reaction.

Especially should the student here make a beginning in connecting his psychology laboratory work with processes and operations of daily life, for nowhere may more concrete illustrations of laws studied in the laboratory be found; and this procedure, if continued and developed, will tend to humanize the science and give it the practical interest for the student which is its inherent right.

SIMPLE REACTION TIME

Experiment 1. To determine Tactual Reaction Time

Material. Stop watch; touch stimulus; blank forms for results.

Procedure. A group of students, ten or more, stand in tandem order, forming a circle around a table or a few chairs, each student turning slightly to the left. One of the members of the circle, termed the starter, holds a stop watch in the right hand. At the signal "Go," given by a student outside the circle, the starter starts the watch, and at the same time, with the index finger of the left hand, taps the right shoulder of the student directly in front. The latter, just as soon as the touch is perceived, taps the student directly to his front with the index finger of the right hand. This process is repeated by each in turn within the circle until the starter's right shoulder is touched. He then at once stops the watch. The right shoulder must be tapped by the right finger throughout the experiment. The students are enjoined to inhibit all forms of distraction during the experiment. At least twenty trials should be made. A student records the results on the board in the form of the table given on page 32.

Results. Subject's report. To what factor in the reaction did you attend particularly? If to the stimulus, the reaction is known as sensory; if to the response, as motor; if the attention is equally divided, the reaction is central. What, then, is your type? Would this type of reaction become unconscious if continued long enough? Did bodily tenseness increase or decrease with the progress of the experiment? Were there any fatigue effects?

Experimenter's report. Construct a table for the results. The table given here is an actual table taken from class results, and the treatment of results is fully explained for future reference.

TABLE II. REACTION TIME TO TOUCH IN A GROUP OF FOURTEEN STUDENTS

Number of Trial	Time (Seconds)	Array (Seconds)	Variation (Second)
1	3.2	2.8	0.165
2	3.2	2.8	0.165
3	3.1	2.8	0.065
4	3.0	2.8	0.035
5	3.0	3.0	0.035
6	3.0	3.0	0.035
7	3.0	3.0	0.035
8	3.0	3.0	0.035
9	3.0	3.0	0.035
10	3.4	3.0	0.365
11	3.0	3.0	0.035
12	2.8	3.0	0.235
13	2.8	3.0	0.235
14	3.2	3.1	0.165
15	3.2	3.2	0.165
16	3.0	3.2	0.035
17	3.0	3.2	0.035
18	3.2	3.2	0.165
19	2.8	3.2	0.235
20	2.8	3.4	0.235
Total	60.7	Ind. median, 0.214	M.V., 0.125
Group average	3.035		
Individual average	0.217	Ind. mode, 0.214	

Explanation. The array is made by placing the numerical results in order of rank from the smallest to the greatest.

The average is found by the formula $\frac{\Sigma s}{n}$,[1] or the sum of the records divided by their number.

The mode is the result, or measure, occurring most frequently. In the table it is 3 sec.

The median is that point on the scale of measurement upon either side of which one half of the total number of measures will fall if arranged in array or rank order. Therefore in the table above the

[1] Σs stands for the sum of the individual records. n stands for the number of individual records.

median lies halfway between the tenth and eleventh measures, and numerically is the average of these two measures, 3 sec. in this case also.

In both cases the results give the reaction time of a group of fourteen, and hence the average individual time is found by dividing the group time by 14. This gives a value for the average of 0.217 sec., for the individual median of 0.214 sec., for the individual mode of 0.214 sec.

The variation of each measure is found by taking the difference between it and the average. The average variation is called the mean variation, or M.V. The uniformity of results is also measured by the range, the distance between the first and the last measure of the array. Here it is 3.4 sec. – 2.8 sec., or 0.6 sec.

Discussion of results. Are the trials fairly uniform in length? If not, can you explain why?

The general inference is given at the end of Experiment 3.

Experiment 2. To determine Auditory Reaction Time

Material. The auditory stimulus consists of a metallic click made by a berry-capper or some similar object that is readily controlled by the experimenter; stop watch, etc., as in the preceding experiment.

Procedure. The students are arranged as in Experiment 1, each being provided with a berry-capper. At the signal "Go," given by one outside the circle, the starter starts the watch and at the same time clicks the berry-capper close to the right ear of the student directly to the front. This process is continued around the circle until the starter hears the click at his right ear. Twenty trials are made.

Results. *Subject's report.* Follow the same plan as in Experiment 1.

Experimenter's report. Follow the same plan as in Experiment 1.

Discussion of results. Do you observe any effects, either objective or subjective, from practice? How does auditory reaction time compare with tactual reaction time in length? Are results fairly uniform? Is your time sensory or motor?

Experiment 3. To determine Visual Reaction Time

Material. Stop watch; fan handle 10 in. long, bearing at one end a white disk 3 in. in diameter; blank forms.

Procedure. The students are arranged as in Experiment 1. The starter holds the watch in the right hand and the stimulus disk in

the left. Other subjects hold the disk in the right hand directly in front. At the signal "Go" the starter starts the watch and at the same time thrusts the disk above his right shoulder. The student behind the starter thrusts his disk above his right shoulder as soon as he sees the starter's disk. The stimulus is thus passed backward around the circle. When the starter sees the disk, he stops the watch. Twenty trials are made.

Results. *Subject's report.* Follow the same plan as in Experiment 1.

Experimenter's report. Follow the same plan as in Experiment 1.

Discussion of results. Compare the reaction time of touch, hearing, and vision as to length. How does your work compare in each case with standard results? How does the reaction studied differ from reflex action? Describe a reaction-time process, including such aspects as mental set, tenseness, post-reactions, nature of distractions. Give at least three examples from daily life illustrating reaction-time situations in each of the three sorts studied above: responses to touch, to vision, and to sound.

Inference. Let your inference include a definition of simple-reaction time and also a statement showing the relative duration for the different sense modes as shown by the results.

READINGS. **2:** 37–47; **3:** 476–486; **4:** 126–131; **5:** 205–211; **6:** 428–436; **15:** 205–211; **17:** Vol. I, Part I, 117–125.

COMPLEX REACTION TIME

EXPERIMENT 4. To determine Discriminative Reaction Time

Material. Visual stimulus as in Experiment 3; the disks are of three kinds, bearing a square, a circle, and a triangle; stop watch; blank forms.

Procedure. The procedure is as in Experiment 3, except that the student raises his disk as soon as he discriminates the figure on the disk seen in front, knowing in advance that it must be a triangle, a circle, or a square. Fifteen or more trials are made. At the end of each trial, stimulus disks are changed, each student quickly passing his disk to the student just behind him.

Results. *Subject's report.* Compare the conditions of this experiment with the preceding one as to the tenseness of attitude. Do results indicate any habit formation? Can anticipation be reduced to a habit?

Experimenter's report. Construct a table and calculate results, as in the preceding experiments.

Discussion of results. Compare the results obtained above with the results of Experiment 1 as to length of reaction. Give three examples of the discriminative reaction from everyday life. In what does a discriminative reaction consist, considering both conditions and processes?

Inference. Give a description of the discriminative reaction.

READINGS. **10**: 487–494; **13**: 131–134; **15**: 211–212; **17**: Vol. II, Part I, 186–187; **18**: 437–442.

EXPERIMENT 5. To determine Choice Reaction Time

Material. The same as for the preceding experiment.

Procedure. Students are arranged as in preceding experiments. At the signal "Go" the starter starts the watch and at the same time thrusts his disk above his right shoulder. When the student at his rear has discriminated the figure on his disk, he makes one of three possible responses. If the figure is a triangle, the response is made by raising the disk over the right shoulder; if a circle, the disk is raised over the left shoulder; if a square, the disk is thrust above the head. To aid in prompt responses, the disks should be held vertical and in front of the median line of the body. Every care should be exercised not to respond until the figure has been clearly discriminated. Fifteen or more trials are made, disks being passed to the rear at the end of each trial.

Results. Subject's report. What distinguishes choice time from discrimination time? What factor in this experiment is similar to an act of the will, so called, in everyday life?

For suggestions as to experimenter's report, discussion, and inference, see Experiment 4.

READINGS. **13**: 131–133; **18**: 439–440.

EXPERIMENT 6. To determine Cognitive Reaction Time

Material. Packs of twenty small cards, each bearing one plainly printed stimulus word, the words all being different but as nearly as possible of uniform length; stop watch.

Procedure. The circle arrangement is used as in preceding experiments. Each subject is given a pack of cards. At the signal the starter starts the watch and at the same time pronounces the word on the top card. As soon as S in front cognizes the word, he responds by pronouncing the top word on his pack. This continues around

the circle to the starter, who stops the watch. As the word is pronounced the card bearing it is placed at the bottom of the pack. This procedure is repeated from the twenty cards.

Results. *Subject's report.* Were the words uniformly familiar? What was the effect of any unfamiliarity?

Experimenter's report. Construct a table of times for each set of words and calculate final results as in Experiment 4.

For discussion and inference see Experiment 4.

READINGS. **15**: 212; **18**: 438.

EXPERIMENT 7A. To compare Free Associative Reaction Time for Concrete and for Abstract Words (Two Students)

Material. Two lists of forty words each, to be used as stimulus words, one list containing only concrete words and the other only abstract words; chronoscope (Sanford vernier type is recommended; for description and directions see Experiment 8A); sheet for recording the time of response and the response word. Stimulus words may be found in the texts given in the bibliography, but in that case they should always be in groups of twenty each and typewritten for class use. Sample lists are given on the opposite page, and these may be used if the subject has not read them.

Procedure. To distribute the effects of practice reactions, present first twenty concrete words followed by twenty abstract words; then return to concrete words, and finally give twenty abstract. E gives the "Ready" signal each time before presenting a stimulus word; presentation may be either visual or auditory, but the mode selected must be uniform throughout.

Results. *Subject's and experimenter's reports.* Table III suggests a form for recording and presenting the results. Observe that there are two sets of results: (1) response words, (2) the time in seconds. Both should be examined critically by E and S together. The response words often point to a "set," or complex, to which they belong.

Discussion of results. The responses in this table were made by a professor of biology. The usual response to "ant," if orally presented, is "uncle," but in this case "hole" (entrance to ant's nest) was given. "Board" occurs three times in response to names of objects made of wood, which was probably due to the fact that the subject was an expert on the strength and structure of different kinds of woods.

The average reaction time to abstract words (see Table III) was somewhat longer than that to concrete words. That the difference, 0.17 sec., was not greater may be due to the fact that the subject

Table III. Association Reactions to Concrete and Abstract Words

	Concrete Words			Abstract Words		
Number	Stimulus Word	Response Word	Time in Seconds	Stimulus Word	Response Word	Time in Seconds
1 . . .	ant	hole	2.86	anger	mad	1.54
2 . . .	bath	water	2.32	ability	good	1.66
3 . . .	bird	fly	1.62	order	fine	1.82
4 . . .	butter	soft	1.64	anxious	hopeful	3.22
5 . . .	car	apple	2.70	bravery	soldier	2.52
6 . . .	cottage	house	2.60	candor	angry	1.94
7 . . .	flag	pole	1.82	conscience	mind	2.76
8 . . .	fan	Japan	1.76	consequence	result	1.92
9 . . .	garden	man	2.44	crude	rough	1.52
10 . . .	hammer	nail	2.48	copious	fat	2.20
11 . . .	light	lamp	1.34	capricious	run	2.24
12 . . .	moon	sun	1.60	curious	queer	1.80
13 . . .	music	play	1.68	association	connect	1.14
14 . . .	ocean	water	1.76	calamity	fatal	1.76
15 . . .	river	water	.50	daring	brave	1.74
16 . . .	salt	sugar	1.60	devout	love	1.86
17 . . .	ship	boat	1.54	defeat	beat	.98
18 . . .	soldier	man	1.46	diffidence	rush	3.32
19 . . .	fly	fly	1.78	demure	meek	1.94
20 . . .	stork	baby	1.74	destroy	devil	1.18
21 . . .	sweater	coat	2.66	doubt	run	5.22
22 . . .	table	board	1.74	duty	wore	2.18
23 . . .	fife	drum	1.66	eminent	great	1.90
24 . . .	window	frame	1.76	eligible	good	2.84
25 . . .	book	leaf	2.18	emancipation	proclamation	2.40
26 . . .	braid	ribbon	2.72	erroneous	wrong	2.04
27 . . .	cake	dough	1.64	error	wrong	1.60
28 . . .	cough	disease	3.20	envy	love	1.78
29 . . .	desk	board	1.62	faith	hope	2.06
30 . . .	dish	crockery	1.66	fury	mad	1.00
31 . . .	floor	wood	1.86	fame	hope	4.80
32 . . .	hat	head	1.80	fidelity	love	1.60
33 . . .	ink	write	1.40	fashion	dress	2.80
34 . . .	paper	write	1.60	generous	hopeful	1.06
35 . . .	lodge	person	5.22	gaiety	bright	5.54
36 . . .	marble	roll	2.32	glamour	green	1.60
37 . . .	orange	juice	2.42	gravity	fall	2.40
38 . . .	pie	eat	1.96	honor	obey	1.86
39 . . .	porch	board	1.84	horror	bad	2.74
40 . . .	house	cottage	2.66	aim	gun	1.86
			Average =2.03			Average =2.20

was well educated. Individuals of limited or grammar-school education give unusually long reactions to abstract words.

These two series of reaction times present a problem that often occurs when it is desirable to compare the relative stability of two series.

Mathematicians offer several ways for determining the stability or, in other words, the reliability of the differences between two averages. The value of the reliability of such differences is theoretical, but it furnishes an approximate answer to the question How many times in a hundred will the amount and direction of difference occur between two series of reactions obtained under similar conditions? Such a value is called the coefficient of reliability of the difference between arithmetic means.

The essential steps in the computation are as follows:

1. Compute the averages for each series. In the present experiment the average for the concrete series is 2.03 sec. and for the abstract series 2.20 sec.

2. Find the average deviation (A.D.) of the responses from the arithmetic mean (average). The average deviation for the concrete series is 0.575 sec. and for the abstract series 0.709 sec.

3. Determine the variability of the arithmetic mean (M.V.). This is the ratio of the average deviation to the square root of the number of responses (measures) in the series.[1] The formula is

$$\text{M.V.}_{\text{Av.}} = \frac{\text{A.D.}}{\sqrt{n}}.$$

Substituting,

$$\text{M.V.}_{\text{Av.}} = \frac{0.575}{\sqrt{40}} = \frac{0.575}{6.324} = 0.09, \text{ for concrete responses;}$$

$$\text{M.V.}_{\text{Av.}} = \frac{0.709}{\sqrt{40}} = \frac{0.709}{6.324} = 0.11, \text{ for abstract responses.}$$

4. Compute the coefficient of reliability of the difference between the arithmetic means. This coefficient consists of the ratio of the difference between the arithmetic means to the square root of the sum of the squares of the variability of the two arithmetic means. Let $\frac{\text{D.}}{\text{M.V.}_{\text{D.}}}$ stand for the coefficient of reliability, where D. is the difference between the arithmetic means and $\text{M.V.}_{\text{D.}}$ is the square

[1] Read symbol $\text{M.V.}_{\text{Av.}}$, "variabilty of the arithmetic mean or the common average."

root of the sum of the squares of the two variables.[1] Also let A represent mean variations of the average (M.V.$_{Av.}$) for concrete responses and B the similar value for abstract responses. Whence,

$$\frac{\text{D.}}{\text{M.V.}_{\text{D.}}} = \frac{\text{D.}}{\sqrt{A^2 + B^2}}.$$

By substitution,

$$\frac{\text{D.}}{\text{M.V.}_{\text{D.}}} = \frac{0.17}{\sqrt{0.09^2 + 0.11^2}} = \frac{.17}{0.142} = 1.2.$$

In order to find the actual number of chances in a hundred corresponding to the coefficient obtained, consult Table 49 in the Appendix. When the coefficient is 1.2, the chances are eighty-three out of one hundred that approximately the same amount and direction of difference would occur between the two series of reaction times.

Were you impressed by many response words at any one time? Was there an element of choice in the response? Indicate the key word and see if you can explain the reason. Why do we begin with concrete words? Why do we change to abstract words? Why do the times for concrete and for abstract words differ? Does this process resemble any mental process that you have experienced in daily life? Compare your free-association time with choice time and with simple-reaction time as to length.

EXPERIMENT 7 B. To diagnose Specific Mental States by the Use of Free Association (Class Experiment)

NOTE. This exercise is given not for its value to applied psychology, but for its training in critical observation of results. The account given is a report of an actual experiment and serves merely as a suggestion.

Material. It is evident that different material for the experiment here described must be provided each time.

A chronoscope of the Sanford type is suggested for this kind of work or, better still, the Johns Hopkins chronoscope, which, of course, requires a special mode of procedure.

Procedure. Students serving as subjects were first assembled in the same room to receive directions, the observers being excluded. The subjects were divided into three groups: Group I was in-

[1] Read the denominators, M.V.$_{D.}$, of the symbol for the coefficient of reliability, "the square root of the sum of the squares of the variability, M.V.$_{Av.}$, of the arithmetic means."

structed to report to Room A for further instruction, Group II to report to Room B for a similar purpose, and Group III merely to return to the laboratory for routine work. In Room A an assistant was waiting with a doll in a doll carriage. As each student entered in turn, not knowing what awaited him, the assistant directed him to roll the carriage across the room a certain number of times. In Room B a second assistant presented in turn to members of Group II a box of candy wrapped in a special manner in tissue paper and tied with a ribbon. The subject was told to open it, take out a piece of candy, eat it, tie the box up as before and return it. As soon as the subjects carried out the directions they were instructed to return to the laboratory and go on with their work. Only the assistants and the instructor knew what the subjects had to do in Rooms A and B, and as it was done during a laboratory period there was no opportunity to compare notes. On return of all to the laboratory the instructor presented for reaction a list of fifty or sixty words previously prepared. These words were of two classes: (1) those having no reference to the special experiences in Rooms A or B (that is, indifferent words); (2) "critical" words, referring to reactions. A list is given below. The critical words are italicized.

1. wheat	11. chalk	21. shovel
2. straw	12. plate	22. boat
3. *flaxen*	13. *carriage*	23. chair
4. label	14. paper	24. *untie*
5. cat	15. *box*	25. roll
6. *hair*	16. sack	26. bitter
7. bread	17. pencil	27. *tissue-paper*
8. *dress*	18. *candy*	28. *taste*
9. river	19. deer	29. *sweet*
10. *doll*	20. string	30. *eat*

Results. Subject's report. This should account for associated words.

Experimenter's report. Two aspects of the responses were noted: (1) the key words that had comparatively long reaction times, that is, words to which the responses with associated words were considerably delayed; (2) the character of the associated word. These special key words, their long reaction times, and the associated words were then grouped and compared in order to see if they revealed a specific experience to which Groups I and II had been subjected. Group III was able to identify the special experience from such a critical study.

Discussion of results. In order that the entire class may benefit by such an experiment, questions should be asked by the instructor to

develop and clear up the different aspects of the experiment. What was the purpose of having Group III in the experiment? What was the value of having two separate experiences, the candy-box experience and the doll-carriage experience? Is there any connection between the evidence as furnished by irregular time reactions and the quality of the reaction?

READINGS. **12**: 219–269; **23**: 324–327.

EXPERIMENT 7 C. To determine Partially Constrained Reaction Time (Two Students)

NOTE. To study the principles involved in partially constrained and wholly constrained association reactions, respectively, observe that the key words in Experiment 7 C may be responded to by a limited number of reaction words, but in Experiment 7 D the key word admits of only one reaction word.

Material. A list of twenty-five transitive verbs; stop watch or clock.

Procedure. The transitive verbs are arranged in a vertical column, as were the words in Experiment 7 A. The lists are distributed blank side up. At the usual signal S turns the paper over and begins with the top word, writing after it a noun which completes the action expressed by the verb; for example, "write" — "letter." S proceeds down the list as rapidly as possible. E observes and records the time. S now rewrites the nouns just written, E keeping the time required, as mechanical time. Deduct this latter time from the total time and divide the remainder by 25 for average rate.

Results. *Subject's report.* Did you discover any connection between the character of the verb and your own personal experience? Would verbs call up several words at the same time? How did you account for this? What sort of inhibition is this?

Experimenter's report. This should consist of the list of associated nouns, that is, the objects of transitive verbs, and the average reaction time duly computed for partially constrained association.

EXPERIMENT 7 D. To determine Wholly Constrained Reaction Time (Two Students)

Material. A list of twenty-five words which have opposites; stop watch or clock with second-hand. A Sanford chronoscope may be used to record the time.

Procedure. Place the prepared list before S blank side up. At the usual signal S turns the paper over and begins with the top word, writing after it its opposite; for example, if the word is "east," "west" is written. S proceeds down the list as rapidly as possible.

E observes the time as before, and S rewrites the words of the list of opposites just written, E keeping the required time.

Results. Subject's report. Note the factor of familiarity of the word of apparent ambiguity. Was there a tendency to give a synonym? Account for this. Can you explain particularly long or short reaction times? (Chronoscope work.)

Experimenter's report. List the words as written and compute the time. Study the results for synonyms, for ambiguous words, and for unusually long or short reaction times if a chronoscope is used.

Discussion of results. Comparison of times in Experiments 7D and 7C.

With the experimental procedure given in the reaction-time experiments as listed above the following table has been obtained from the records of two hundred and twenty individuals:

TABLE IV. AVERAGE RESULTS OF TWO HUNDRED AND TWENTY INDIVIDUALS

SIMPLE REACTION TIME IN SECONDS		COMPOUND REACTION TIME IN SECONDS	
Tactual	0.222	Discrimination	0.434
Auditory	0.219	Choice	0.878
Visual	0.238	Cognition	0.551
		Free association	0.866

Inference. An inference should be given here for Experiments 7 A to 7 D, inclusive, defining associative-reaction time and the types studied, giving durations found and the principle involved in 7 B.

MEASURING REACTION TIME WITH INSTRUMENTS OF PRECISION

The following exercises on reaction time give opportunity for individual work and for becoming familiar with the use of an instrument of comparatively high precision. After Experiments 8 A, 8 B, and 8 C have been completed, a comparative discussion should follow.

EXPERIMENT 8 A. To determine Simple Reaction Time to Touch (Two Students)

Material. Sanford's vernier chronoscope; tabulating paper.

The vernier chronoscope depends upon the application of the principle of the vernier to time. The essential structures of the chronoscope are shown in the accompanying photograph. It consists of a cast-iron base *b*, 15 cm. by 10.5 cm. and 2.7 cm. thick, and of an upright post *U* 19.5 cm. high. From the upright projects at a right

TABLE V. RESULTS FROM SIMPLE REACTIONS TO TOUCH

Trial	Stimulus	Time in Seconds	Subject's Report
1 . . .	Touch	0.20	Anxiously waited for the stimulus, wondered if I would be ready: tightened my finger on the key
2 . . .	Touch	0.22	Stimulus was so long in coming that I thought E was trying to catch me unawares; counted swings of short pendulum
3 . . .	Touch	0.20	Wondered if I was doing my part of the experiment correctly; imaged the swinging pendulums
4 . . .	Touch	0.18	Thought of Mrs. X and her lecture on Courts of Justice; surprised to find I reacted almost automatically
5 . . .	Touch	0.20	An itchy feeling where the stimulus is applied; key finger feels too slack, reaction seems slow
6 . . .	Touch	0.18	Watched E's movements; scarcely noticed stimulus when I reacted
7 . . .	Touch	0.22	Miss B entered the room and I thought of work I had to do for her
8 . . .	Touch	0.20	Wondered if I kept mind on stimulus if the reactions would be more uniform
9 . . .	Touch	0.18	No report
10 . . .	Touch	0.24	Wish I could rest now

Average = 0.202 Mode = 0.20 Median = 0.20

EXPERIMENT 8 C. To determine Motor Reaction Time to Touch (Two Students)

NOTE. This experiment is conducted in exactly the same manner as the two above, with the exception that S's attention is given to the movement that releases the short pendulum. S and E each perform thirty trials.

Results. Record results, tabulate, and compute as in the two preceding experiments. Also arrange the averages, the modes, and the medians of Experiments 8 A, 8 B, and 8 C for purposes of comparison. Note the changes that occur in S's reports of Experiments 8 B and 8 C.

Discussion of results. After studying your own results and reading one or more of the standard texts listed on simple reaction time, answer the following questions: Of the three types of reaction time, — natural (or central), sensorial, and motor, — which shows the highest uniformity, that is, constancy in response? How may the constancy be computed? Which of the three types shows the greatest

amount of improvement? If the motor type of reactions had been performed first, the natural type second, and the sensorial type last, would the results have been materially changed? How may the effects of habit and fatigue be eliminated from the results of the three types of reaction time?

Inference. ____

EXPERIMENT 9. To determine Simple Auditory Reaction Time (Two Students)

Material. Chronoscope; eight-penny nail or penknife.

Procedure. S makes the same adjustments in these experiments as in the three preceding ones, closing his eyes before each trial and maintaining as comfortable a position as possible. E gives the signal "Ready," and S places his right forefinger on the key of the short pendulum; then after one or two seconds E taps the key of the long pendulum with the flat surface of the nail head, making a sharp, metallic sound. S releases the short pendulum as soon as the sound is heard. After ten trials E and S exchange places. Each should make thirty trials, performing the motor reactions first, the sensorial reactions second, and the natural reactions last.

Results. Record results, tabulate, and compute averages, medians, etc., as in preceding experiment.

Discussion of results. Is there any ground for believing that touch reactions have in part, at least, an innate neuro-muscular mechanism? Can the same answer be made regarding the responses of the hand-to-sound stimulus? Compare the range of improvement of the touch-hand reactions with those of the ear-hand responses. Compare them as to uniformity. Compare your results as to rate with those given in standard texts.

Inference. ____

EXPERIMENT 10. To determine Simple Visual Reaction Time (Two Students)

Material. Chronoscope provided with the following accessories: a bit of cotton wool under the stimulus key to deaden sound; a stimulus card of white or colored paper 5 mm. square placed in the jaws of the receiving clip *St* (Fig. 1, p. 43) situated on the horizontal arm; a small screen card cut to a convenient size and fitted into the jaws of the bull-dog clip *Scr*.

Procedure. S should be seated so as to observe easily the stimulus card when it is exposed. E calls "Ready" and removes the screen

automatically from the stimulus card when pressing the key of the long pendulum. E and S each make thirty trials in determining each of the three types of visual reaction time.

Results. The results are to be used in the same way as those of the two preceding experiments. Make a comparative table showing the averages, medians, and modes for the three types of reaction to touch, auditory, and visual stimuli.

Discussion of results. As the reactions become more habitual, does the character of the subject's report undergo an appreciable change? Which type of reaction shows the greatest tendency readily to become habitual? Upon what evidence do you base your answer?

Inference. --

Experiment 11. To determine Discriminative Reaction Time (Two Students)

Note. Exercises for measuring other compound forms of reaction time may readily be devised.

Material. Chronoscope; four bits of colored paper; for example, blue, green, red, and yellow, each 5 mm. square.

Procedure. S is told the four colors that will be used but does not know which one in any particular trial. E places the stimulus paper in the clip and calls "Ready" and after a short interval exposes, say, the red paper by releasing the stimulus key. S calls "Red" as soon as the color is recognized and simultaneously releases the short pendulum.

The experiment is repeated sixteen times, varying the sequence of colors. E should expose a gray or a white paper occasionally.

Results. Compute the average and the median. Work out discussion and inference as usual.

OTHER EXPERIMENTS IN MOVEMENT REACTION

Experiment 12. To determine the Precision of Voluntary Arm-Hand Movement (Two Students)

Note. Precision of movement was investigated first in this country by W. L. Bryan in 1892, and later, in 1903, by T. L. Bolton and others. The apparatus used by Bryan was standardized as to form and size by G. M. Whipple in 1910, and is recommended for experimental purposes (see tracing board in Fig. 2, p. 48).

Material. Fig. 2 shows the several pieces of apparatus assembled for use. A sounder *S* is preferred to an electric bell, as the ring of the latter is too distracting. The metal stylus for tracing is 1 mm.

in diameter and moves on a glass strip in the bottom of the groove. The sides of the groove consist of two brass strips 25 cm. long placed 0.5 cm. apart at one end and 0.2 cm. at the other. Since the groove decreases in width at a uniform rate from the large to the small end, it follows that the decrease per centimeter is 0.12 mm., for

$$\frac{0.5 \text{ cm.} - 0.2 \text{ cm.}}{25} = 0.012 \text{ cm., or } 0.12 \text{ mm.}$$

Table VI shows the width of the groove at each centimeter on the scale and also the extent of lateral deviation from the mid-line of

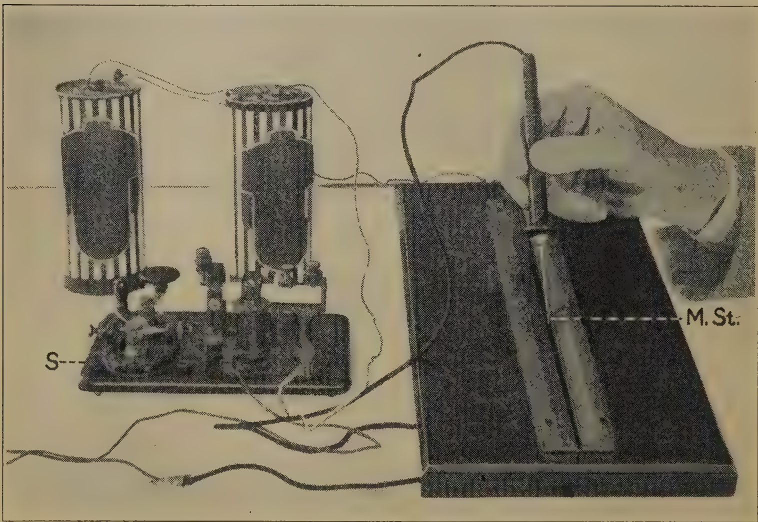

FIG. 2. Apparatus for testing precision of movement
M. St., metal stylus; *S*, sounder

the groove whenever the stylus touches the brass strip at that point of the scale; these extents are computed by taking half the difference between the entire width of groove at point of contact and half the diameter of the stylus. Half of the diameter of the one in Fig. 2 is 0.5 mm.; thus:

$$\frac{4.04 - 0.5}{2} = 1.77,$$

4.04 mm. being the width of the groove at the 8-centimeter point and 0.5 mm. half the diameter of the stylus.

A tracing groove with different dimensions would require, of course, the computation of a new table.

Table VI. Width of Tracing Groove per Centimeter and Possible Extent of Stylus Deviation

Centimeter on Scale	Width (Millimeters)	Extent of Deviation (Millimeters)	Centimeter on Scale	Width (Millimeters)	Extent of Deviation (Millimeters)
0	5.00	2.25	13 . . .	3.44	1.47
1	4.88	2.19	14 . . .	3.32	1.41
2	4.76	2.13	15 . . .	3.20	1.35
3	4.64	2.07	16 . . .	3.08	1.29
4	4.52	2.01	17 . . .	2.96	1.23
5	4.40	1.95	18 . . .	2.84	1.17
6	4.28	1.89	19 . . .	2.72	1.11
7	4.16	1.83	20 . . .	2.60	1.05
8	4.04	1.77	21 . . .	2.48	0.99
9	3.92	1.71	22 . . .	2.36	0.93
10	3.80	1.65	23 . . .	2.24	0.87
11	3.68	1.59	24 . . .	2.12	0.81
12	3.56	1.53	25 . . .	2.00	0.75

Procedure. Concerning this experiment Bryan observed that the position of the instrument in relation to the body, the muscles employed, the support of the muscles used, the distance moved affecting variously readjustments of the muscles while in motion, and the rate of motion all affect the results. In the present experiment confine your study to three factors: (1) the effect of direction, (2) the effect of handedness, (3) the effect of rate of movement.

Two series of observations are made, the first one at a rate of motion such that the entire groove is run in 12 sec. and the second one at a rate that runs the groove in 8 sec. In each series twenty tracings are made in each of four directions: (1) moving out from body, (2) moving in, (3) moving to right, (4) moving to the left. Make ten trials with each hand for the directions specified, beginning always, of course, at the wide end and moving at an even, continuous rate. The stylus is held pen-fashion and the arm and hand, unsupported, move from the shoulder. For the moving-out trial place the tracing board on the table so that the groove falls in line with the median plane of the body. S should make a few preliminary trials preceding both series to become familiar with the rate of moving. E gives "Ready, go" signal before each trial. When the experiment proper begins, a click from the sounder *S* is a signal for S to stop instantly and hold the stylus in place (but not against the brass strip) until E takes the reading. By referring to Table VI deviations in millimeters can be read off and entered on the record sheet.

For example, if the stylus made contact with brass strip at the 10-centimeter point, the amount of deviation is 1.65 mm., or if the stylus touched at 10.5 cm., then by interpolation the reading would be 1.62 mm. Make five trials with each hand, alternating the right and the left hand; then turn the board through 180 degrees and trace toward the body, making five trials with each hand, alternating as above. Make the same number of trials, moving from right to left and from left to right of the median plane of the body. Now place the board in the first position, with the groove extending in front of the body, and make five more trials with each hand, alternating, thus making a total of ten trials with each hand. Continue the round in the same manner: toward the body, to the right, and to the left, until ten trials are entered for each hand in all four directions. E and S now exchange places and repeat the first series. The second series had better be done at a later sitting.

Results. The headings given here suggest a form for entering the records.

TABLE VII. THE EFFECT OF RATE, DIRECTION, AND HANDEDNESS ON ACCURACY OF MOVEMENT

TRIAL	RATE TWELVE SECONDS PER TRIAL								RATE EIGHT SECONDS PER TRIAL							
	Out		In		Right		Left		Out		In		Right		Left	
	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.
1																
2																
3																
etc.																

Discussion of results. Compare the averages of the total (80) deviations for each rate. Compare the averages of total deviations for right and left hand, respectively, for each rate separately and for both rates combined. Are your hands, as a rule, equally precise and accurate? What do the results indicate about the relative precision of your hands? Compare likewise the averages for *out* and *in* directions. Treat similarly tracings for *left* and *right* directions. Did your tracings improve with repetition? From your experience in this experiment and from that in doing other things with your hands, what do you regard as the chief factors in voluntary movements? Have you convincing evidence that the results were affected by a change of attitude? of attention?

Inference. ______________________________________

For special reading see:

BRYAN, W. L. "On the Development of Voluntary Motor Ability," *American Journal of Psychology*, Vol. V (1892), pp. 53–72.

HANCOCK, J. A. "Preliminary Study of Motor Ability," *Pedagogical Seminary*, Vol. III (1894), pp. 9–29.

LANGFELD, H. S. "Voluntary Movement under Positive and Negative Instruction," *Psychological Review*, Vol. XX (1913), pp. 459–478.

WHIPPLE, G. M. Manual of Mental and Physical Tests, Simple Processes, pp. 151–155. Warwick & York, 1910.

WOODWORTH, R. S. "The Accuracy of Voluntary Movement," *Psychological Review*, Monograph Supplement, Vol. III (1899), pp. 2–53.

EXPERIMENT 13. To determine the Effect of Suggestion on Involuntary Movements and Steadiness

Material. Ataxiagraph; steadiness headboard; glazed paper; gum camphor; artist's fixing solution; wire clips.

One form of an ataxiagraph is shown in Fig. 3. It consists of two metal tubes (bamboo or other tough reed material would do equally well); the outer tube *O.C.* is 90 cm. long and 1.4 cm. in diameter; the inner tube, moving freely in the outer, is 8 cm. long and 1 cm. in diameter; a tracing-point, or stylus, *T.P.*, moving freely, vertically projects 1.7 cm. below the end of the inner tube. The lifting pin is used to raise the stylus slightly whenever the latter presses too hard on the smoked paper. The long tube secured by a clamp is adjustable to the subject's height. The headboard may be made by tying with strong cord a heavy piece of cardboard, 20 cm. by 25 cm., to the top of an outing cap. A mortar board will answer the purpose. Several such headboards of different sizes should be made. Affix the glazed paper to the cardboard with wire clips and blacken it with camphor smoke. It is then ready to be tied on the subject's head, the cord passing under the subject's chin.

Procedure. 1. *Preliminary.* Before beginning the experiment proper it is necessary to determine S's "normal" head-body steadiness. Do this by taking four tracings as follows: E requires S to stand erect directly under the ataxiagraph, hands at sides,[1] heels almost touching and toes out soldier-fashion. If S is a normal adult person, the area of the smoked paper may be divided into four quarters and one tracing made in each quarter. Subjects suffering from *static ataxia* require the entire area of the paper (see case 5 in Fig. 4,

[1] Professor Jastrow has designed automatographs for studying involuntary movements as expressed by the hands. See special reading at end of experiment.

also cases 1 and 2 showing typical extent of normal tracing). E now adjusts the stylus to the center of one of the quarters of the cardboard and instructs S to close eyes and to hold head and body still for one minute. E gives the signal "Now" at the beginning of the minute and "Stop" at the end. S relaxes head and body while the stylus is being adjusted for a new tracing. As soon as four tracings are secured E removes the headboard and immerses the tracings in the fixing solution.

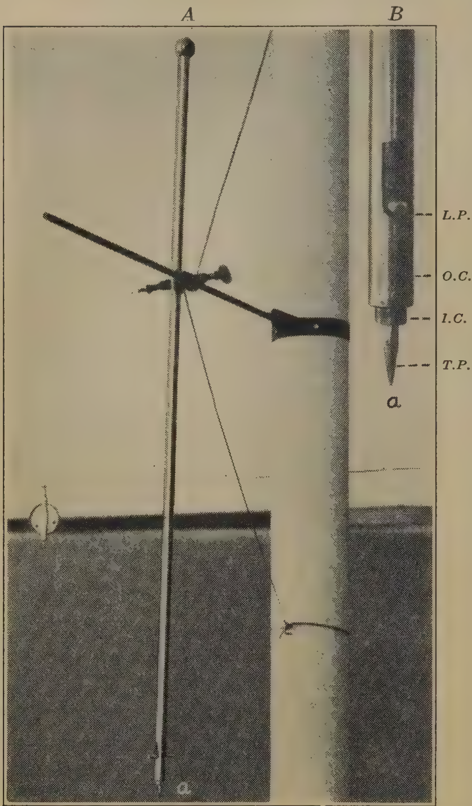

FIG. 3. Ataxiagraph

A, instrument with support rod and guy wires; *a*, tracing-point. *B* (inset), enlarged view of two tubes and tracing-point; *L.P.*, lift pin; *O.C.*, outer tube: *I.C.*, inner tube; *T.P.*, tracing-point

2. *Procedure proper.* The experiment proper may now begin. The success of the work depends upon S's maintaining an impersonal attitude toward the probable results and keeping a *steady head*; breathing should be moderate and uniform. Just before the signal "Now" is given for each tracing S is instructed to think of himself as making a familiar movement (to be suggested by E, of course), while trying to maintain a *steady head.* Four sample movements are here suggested, and the student is referred to Jastrow's *Fact and Fable in Psychology* (pp. 307–336) for a wide range of suitable suggestions.

First suggestion. Imagine yourself running rapidly around a circular dining-room table.

Second suggestion. Imagine that you are pulling only on the right oar of a rowboat.

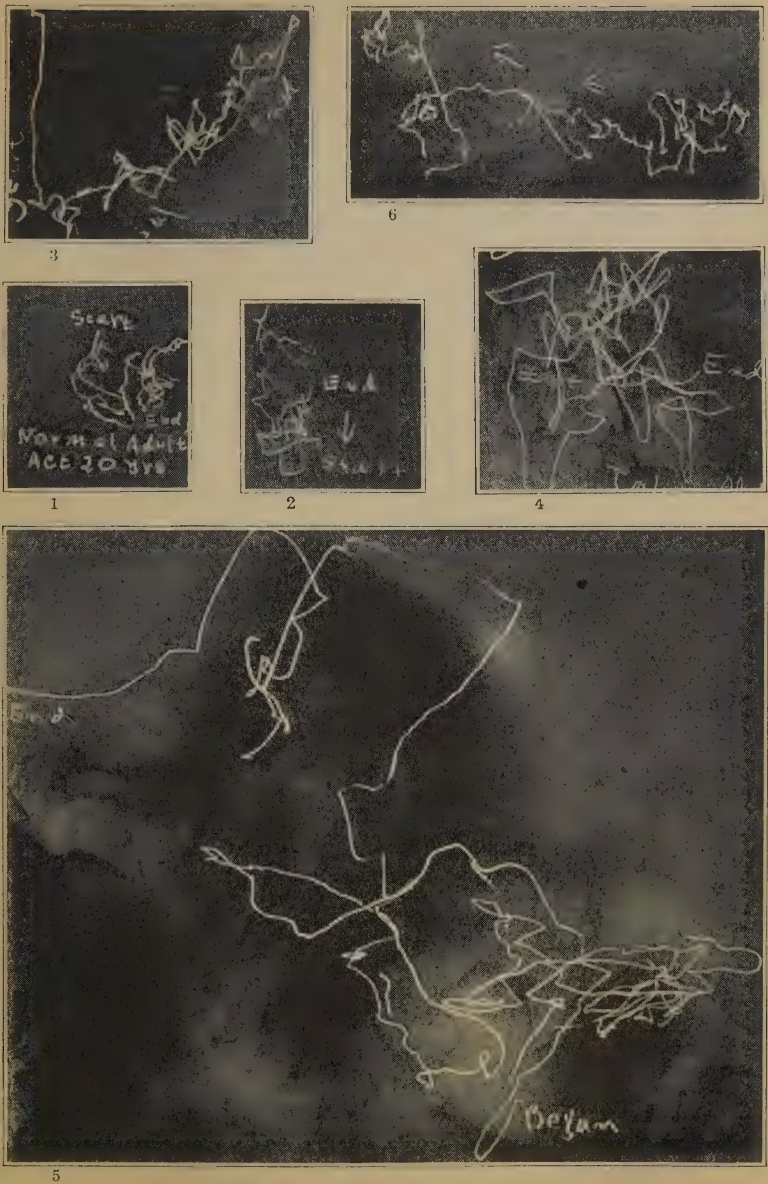

FIG. 4. Tracings of involuntary movements of normal adults and children, also of two astatic children. See text for description

Third suggestion. Think of writing your name from right to left, beginning the first initial at the extreme right of a page and finishing with the last letter of your surname to the extreme left. (Make sure that S understands the suggestion before giving the signal.)

Fourth suggestion. Think of swimming rapidly on your back.

E then gives signal "Now" and starts the stop watch, and S tries to keep body and head steady for one minute. Stylus is adjusted for second tracing. For correct identification, number each tracing as soon as it is finished and mark points of starting and stopping; they are then ready for the fixing bath.

Results. Mount the tracings *with* suggestions and those *without* suggestions on separate sheets. The amount of unsteadiness or swaying movement may be expressed in linear or in areal units. If in the former, the amount of anterio-posterior and of lateral swaying is shown in centimeters, and if in the latter, the unit of measure is square centimeters. The areal method is recommended for measuring pathological unsteadiness and the linear method for the effects of artificial stimuli on normal steadiness. Fig. 4 shows tracings made by six subjects in a comparative study of normal and defective steadiness and also of adult and child steadiness.

TABLE VIII. HEAD-BODY SWAYING

CASE	SEX	AGE	PHYSICAL CONDITION	AREAL UNITS OF UNSTEADINESS (SQUARE CENTIMETERS)
1	Female	20	Normal	3.57
2	Female	19	Normal	3.60
3	Male	10	Normal	18.00
4	Male	7	Normal	18.06
5	Male	10	Defective in motor control	148.50
6	Male	9	Nervous and excitable	21.00

To measure the anterio-posterior and the lateral swayings use a try-square and a millimeter scale. Draw an anterio-posterior line passing through the starting-point of the tracing; then draw a lateral line at right angles to the former, intersecting at the starting-point. Such a drawing of lines shows the effect, if any, of the suggestion on involuntary movement.

Discussion of results. The record should state whether or not S had anticipated or knew what the outcome of the experiment would be.

Inference. ____

For special reading see:

HANCOCK, J. A. "Preliminary Study of Motor Ability," *Pedagogical Seminary*, Vol. III (1894), pp. 9–29.

JASTROW, JOSEPH. Fact and Fable in Psychology, pp. 308–336. Houghton Mifflin Company, 1900.

TITCHENER, E. B. Experimental Psychology: Instructor's Manual, Qualitative, pp. 158–162. The Macmillan Company, 1901.

EXERCISES

Reaction time is defined in the introduction as the interval between the application of a stimulus to the subject and his response to it in a prescribed manner. It is presumed that the response is made as soon as the subject is aware of the stimulus. The reaction-time situation, therefore, consists of the following phases: (1) known stimulus, (2) known response, (3) response following immediately on awareness of stimulus.

In the following exercises, pick out the *true* reaction-time situations, and identify the kinds (for example, simple, visual; complex, choice; etc.), giving phases.

1. Answering red and green signals in traffic.

2. Response to signals in gymnasium exercises, as "Right," etc.

3. At a dinner, forks, knives, and spoons are at one's place. One uses them at the proper time.

4. At a dinner the hostess presses a button. The maid comes to remove the dishes.

5. Games, as "Tag," "Drop the handkerchief," etc.

6. Response of Mohammedans to the muezzin's call to prayer.

7. A young man, after debating whether to attend Harvard, Yale, or Princeton, decides on Yale.

8. The fire alarm rings and response is made by the fire company.

9. An automobile bound for a certain place comes to a crossroad with finger boards. The driver notes his destination and turns into the proper road.

10. A mother calls her child by name, and he comes.

11. John is invited to Mrs. B's and Mrs. C's for the same date to dinner. There is a pretty girl at Mrs. B's, but Mrs. C always has the best dinner. John goes to Mrs. C's.

12. Separating breeds of chickens on a farm.

13. The gong rings for the horse race to begin, and the start is made.

14. The mechanic watches for a certain signal from his machine, and acts when he sees it.

15. Large and small peanuts are sorted in a peanut factory.

16. The conductor on the street car receives a fare; he pulls a rope. He wishes the car to stop; he pulls another rope.

17. Mary goes to a store to buy a dress. She looks at a red one and a blue one. Red is more becoming, but blue is the style, and Mary buys the blue one.

18. Hamlet's final decision, "not to be."

19. The pistol shot is given, and the trained animal starts his performance.

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CHAPTER IV

SENSATIONS

1. This great source of most of the ideas we have, depending wholly upon our senses, and derived by them to the understanding, I call SENSATION.
JOHN LOCKE, *Human Understanding*, Vol. I, Bk. II, p. 226

2. A sense organ is a portion of the body that has very high sensitivity to some particular kind of stimulus. — R. S. WOODWORTH, *Psychology: A Study of Mental Life*, p. 188

3. Sensation is a purely mental fact, which is only referred to a bodily fact by way of explanation of its origin. — G. H. LEWIS, *Problems of Life and Mind*, p. 262

4. The analysis of complex objects may be carried to such a point that we obtain factors which resist any further analysis. Such factors, for example, are redness, sweetness, and cutaneous pain. . . . These ultimate results of analysis are called simple sense data. — KNIGHT DUNLAP, *Elements of Scientific Psychology*, p. 38

TOPICAL OUTLINE

General Problems
- *A*. Innate characteristics
  - I. Criteria of sensations (probable number)
  - II. Relation to other kinds of reaction
- *B*. Physical conditions
  - I. Stimulus
    - 1. Amount
      - *a*. Minimal
      - *b*. Maximal
      - *c*. Range
    - 2. Kind
      - *a*. Mechanical energy
      - *b*. Chemical energy
      - *c*. Radiant energy
      - *d*. Vibratory energy: ether, air
  - II. Receptors, proprio-ceptors, intero-ceptors, extero-ceptors
    - 1. Distribution
    - 2. Essential structures
    - 3. Protective and accessory parts
    - 4. Relation to afferent neurone
  - III. Neural tissue
    - 1. Afferent neurones (arrangement of)

- 2. Central neurones
  - *a.* Sensory area (receiving surface, general and special)
  - *b.* Association area (integrating and differentiating areas)
  - *c.* Motor area (general and special)
- 3. Efferent neurones

IV. Reactors
- 1. Muscles (striped and unstriped)
- 2. Glands (with and without ducts)
- 3. Vascular systems
- 4. Cortical neurones

C. Attributes

I. Common
- 1. Quality (number and kind)
- 2. Intensity
- 3. Vividness
- 4. Value or tone

II. Pseudo-attributes
- 1. Duration (initial and terminal lag, latent period)
- 2. Extension and volume

III. Special
- 1. Adaptation
- 2. Contrast
- 3. Fusion and blend
- 4. Mixture
- 5. After-image, perseveration
- 6. Fatigue

D. Function

I. Make experience possible
- 1. Specialize experience
- 2. Increase variety of experience

II. Make initial adjustments: warn, protect, guide

III. Furnish elemental æsthetic experience

Special Problems

A. Relation between amount of stimulus and intensity of sensation

I. Limen
- 1. Threshold
- 2. Difference
- 3. Upper

II. Methods
- 1. Minimal changes
- 2. Average error
- 3. Right and wrong cases
- 4. Order of merit

B. Number and classification of elemental sense qualities

I. Basis of classification (character of stimuli, quality of sensation)

C. Genesis of the senses in the individual

I. Periods of development (differences in sense acuity)

II. Impairment of the senses with age and by use

INTRODUCTION

Problems furnished by sensation. Two names are used to designate the ultimate kinds of conscious experience: "sensations" and "feeling" (affection). The experiments of this chapter are confined to the problems of sensation. General problems relate to the innate character of sensations (including their relation to other kinds of reaction), to their physical conditions, and to their attributes and rôles in human behavior. Special problems seek to determine the quantitative relation between varying amounts of stimulus and corresponding sensation intensities, to find useful ways for classifying sensations and their respective stimuli, and to set up criteria by which the elementary senses may be satisfactorily identified. A comparative study of the senses belongs to the field of comparative psychology and involves the study of their evolution in animal life as well as their genesis and development in the individual.

1. It is obvious that sense organs are inherited and that they attain functional maturity unaided by experience. But that sensations are innate is not so apparent, partly on account of the fact that we seldom associate the principle of innateness with conscious experience of any sort. And yet functional maturity of any sense organ means that its use is accompanied by sense experience. "The senses are provided by nature and the fundamental use goes with them. The child does not learn to see or hear. . . . He gets sensations as soon as his senses are stimulated" (**26**: 187). Conscious experience as meaningless sensations is an innate reaction.

2. With a few notable exceptions our sense organs are modified epithelial cells connected with afferent neurones, usually provided with protective and accessory tissues, and capable of changing physical energy into a nerve impulse; or, according to one author, "a sense organ is a portion of the body that has a very high sensitivity to some particular kind of stimulus" (**26**: 188).

The structural parts of a sense organ concerned in the first experiment on the sense being studied should be drawn and duly

labeled; a mere inspection of models, sections under the microscope, or the figures in a text does not give adequate working knowledge of the anatomy of the senses. Drawings should be made not only of the more complicated organs — eye, ear, taste bud, touch organ, etc. — as a whole but also of one or more of the essential parts in detail, furnishing a close-up view.[1]

3. All sensations as such possess certain characteristics in common which are termed their properties, or attributes. The attributes generally agreed upon are quality, intensity, and clearness. Quality, as an attribute, endows the sensation with its individuality and is the means by which a particular mode is distinguished from every other; it also gives the particular sensation its distinctive name; for example, "pressure," "warmth," "yellow," "sweet." Intensity is the amount of the sensation and is referred to as its strength or weakness, loudness or faintness, brightness or dullness, weight or lightness. Such expressions as "pale green," "shrill note," "intensely bitter" relate to the attribute of intensity of these several sensations. The property of clearness, or vividness, determines the place of sensation in consciousness with respect to so-called focal and marginal areas. A vivid sensation occupies the focus or foreground in consciousness, while the less vivid, or obscure, remains in the marginal field. It is believed that this attribute of sensation is an index to the readiness of the motor centers of the cortex to discharge into the centrifugal neurones.

4. Certain accompanying aspects of a sensation, such as temporal, spatial, and affective tone, are regarded by some authorities as real attributes, but as they do not form integral parts of the experience in question they are here termed pseudo-attributes. Temporal and spatial aspects of a sensation may justly be regarded as a part of the condition in which it appears and runs its course. Affective tones are more adequately accounted for as independent mental elements having their own attributes.

[1] Satisfactory results may be secured by having drawings made from balopticon projections on an aluminum screen. This enables a large class of students to use the same specimen at the same time. Diagrams, photographs, and figures taken from textbooks and other sources make suitable slides for a balopticon.

5. In addition to common attributes there are special attributes peculiar to certain sense modes but in greater or less prominence, depending on the mode. (The term "mode," as here used, designates a homogeneous group of sensations separated from other groups common to the same sense; for example, warmth and cold sensations may be referred to as the warmth and the cold mode, respectively. The same usage applies to chromatic and achromatic visual sensations, etc.) These attributes are adaptation, contrast, fusion and blend, mixture, and after-image. Fatigue is sometimes included in this group, not as an inherent property but as a striking characteristic of certain sensations, such as smell, taste, and touch.

6. The functions of sensations are several: they furnish the primary elements of all knowledge; they specialize experience in that "each sense organ furnishes us its own particular kind of information in its own particular way"; they instigate movements other than those supplied by innate mechanisms and thereby extend the range of possible adjustments; they furnish elemental æsthetic experience common to vision, sound, taste, smell. The earlier view limited their function to that of furnishing the elements of knowledge, but the influence of the doctrine of evolution on the interpretation of mental function developed the notion that the primary rôle of sensation is the arousal of movements which supplement and eventually replace in part the native reaction.

Special problems and methods. The relations between stimulus and sense organ, between sense organ and sensation, and indirectly between stimulus and sensation furnish a wide range of problems, which were the first to receive scientific treatment.

1. A study of the relation between stimulus and sense organ has reciprocally extended our knowledge of both and raised problems for further study. The arrangement of the retina into different zones of sensitivity to the same hue, and the variation in the response of the taste buds according to their location in the tongue, are illustrations of facts learned in such studies. The anatomy and physiology of these structures give no clue to such facts.

2. A study of the relation between sense organ and sensation reveals knowledge of each in the same reciprocal fashion. The criterion of a sensation is the presence of a distinct and special sense organ, and likewise the *specific energy* of a sense organ is attested by the uniform quality of the sense reaction.

3. Observations on the relation between stimulus and sensation have led to the formulation of several methods designed to control the order and amount of stimulus applied to a sense organ and to maintain uniformity in both space and time units in applying the stimulus and in the reaction to it. These methods, which are described briefly in connection with the experiments in which they are used, are known as psychophysical. Their use has contributed much of permanent value to psychology. Among the achievements the following may be named: (1) The determination and expression of stimulus in mathematical units — movement stimulus is expressed in millimeters (mm.); auditory, in vibrations per second (V.S.); tactual, in milligrams (mg.); temperature, in degrees Fahrenheit or centigrade (F. or C.); brightness, often in candle power (C.P.). (2) The determination of minimal and maximal reactions of a given sense quality. These extremes of reaction are often termed the lower and upper limits of sensation intensities. Closely allied to these determinations is that of difference threshold [1]; that is, the least perceptible difference between two sensation intensities of the same quality. These differences, when expressed in relation to the total stimulus, form a constant ratio within a limited range of intensities of the same sense mode. (3) The determination of individual differences in sensitivity, in the acuity of discrimination, in comparison of judgment, and in the influence of fatigue and practice on output of work.

4. The problem of classifying stimuli, sense organs, and sensations has been but partly solved; it will doubtless form a field

[1] The threshold of sensation, sometimes referred to as the limen, is the least intensity of a sensation that is just observable, and the stimulus by which the sensation has been aroused is termed the just observable stimulus. Obviously the threshold shifts or changes with conditions of fatigue, states of expectancy, and familiarity with the stimulus.

for study and discussion for some time to come. Since these three are so intimately related in psychology, it is obvious that the classification of one of the factors will affect the other two; hence it has come about that the more useful classifications have taken all three into account. For further discussion see **1**: 67–68; **4**: 40–43; **23**: 55–57; **28**: 95–100.

The experiments that follow have been selected with a view to inducing students to formulate the more common laws relating to sensation and to become acquainted with some of the methods used in this field.

DERMAL SENSES

Sensation of Pressure and of Touch

The purpose of Experiment 14 and of similar ones following is to show the sensitivity of the sense organ, its particular kind of stimulus, and the threshold above which stimuli must pass to cause sensation.

Experiment 14. To determine Just Observable Stimulation of Pressure: Method of Minimal Change (Two Students)

Material. Needle and thread; two dozen pieces of thin cardboard 1 cm. square, each weighing from 0.03 to 0.04 g.; piece of chamois skin 2 cm. in diameter.

Procedure. Increasing the weight. S lays hand on table palm side up and closes eyes. E places chamois skin on S's palm posterior to middle finger and, by means of the thread, slowly lowers the cardboard until it rests on the chamois skin. S is told to say "yes" if the cardboard is sensed; it is improbable that two or three pieces will be felt. E takes up the card by the string and strings another bit of card on the thread and applies the weight as before. Cards are added, one at a time, until S responds "yes." To check the responses S is required to answer when no weight is sensed. E counts and records the number of pieces of card strung on the thread.

Decreasing the weight. With chamois skin at same place on the palm E places on the string double the number of cardboards giving the just noticeable pressure sensation found above, and S responds as before. E now removes one card from the stack, not from the thread, by pulling it up to the eye of the needle. The weight minus

the one card removed is again lowered and a response called for. This is repeated until S answers "no." E now counts and records the number of cards that failed to produce a sensation.

Repeat both ascending and descending series.

Results. Experimenter's report. Give the number of pieces of card used in the increasing series and the final number used in the decreasing series, and also the weight of the total number of cards used. Divide the total weight by the number on the string to obtain the weight per card. Knowing the weight per card, compute in milligrams the weight for both increasing and decreasing series. The average of these weights is the just observable stimulus for passive pressure sensation.

SAMPLE OF TYPICAL RESULTS

Number of cards sensed on ascending series = 8;
weight = 8 × 0.0312 g. = 0.2496 g.
Number of cards sensed on descending series = 15;
weight = 15 × 0.0312 g. = 0.4680 g.
Number of cards sensed on ascending series = 11;
weight = 11 × 0.0312 g. = 0.3432 g.
Number of cards sensed on descending series = 14;
weight = 14 × 0.0312 g. = 0.4368 g.
Average of four determinations = 0.3991 g.

Discussion of results. Why was the chamois skin used? Why was its weight ignored in computation? Look up some other method for determining just observable stimulation for pressure.

Inference. Let your conclusion state the meaning of the just observable stimulation for pressure.

READINGS. 4: 151–152; 6: 283; 10: 362–365; 19: Part I, p. 13; 20: 926.

EXPERIMENT 15. To determine the Just Observable Stimulation of Touch (Two Students)

Material. Ten small corks 3 cm. in length; horsehair and human hair, varying in degrees of flexibility; sensitive balance; sharp knife; rubber stamp. The following pressure values of hairs have been found practicable: 0.07 g., 0.01 g., 0.04 g., 0.06 g., 0.08 g., 0.1 g., 0.25 g., 0.48 g., 0.56 g., 0.62 g.

With the aid of the scale pan of the sensitive balance, select a series of ten hairs varying in flexibility; arrange them roughly in the order of their flexibility. Set each hair in a separate cork holder

by drawing it firmly into a slit in the cork to the depth of 1 cm. Clip the hair close at one end and allow it to project 1.5 cm. at the other. Determine with care the touch value of each hair by pushing it down vertically in the pan of the balance and taking the reading just as the hair is about to bend. Print on the end of the cork the weight thus registered. This weight is the touch value of the hair held by the cork. Treat the other nine similarly, making a series of ten touch values in milligrams.

Procedure. 1. *Preliminary.* S places his hand and forearm, volar side up, on a table, and E marks with the rubber stamp one hundred cross sections 1 mm. square, on the palm just back of the ring finger, on the wrist, and on the upper arm. E takes a cork and explores a row of square millimeters as made by the rubber stamp on the forearm for definite touch sensations; the cork should be held vertical to the surface and make a visible depression in the skin at each point of application. To avoid tickling sensations, push the cork down firmly and steadily. S, with eyes closed, says "There" when a clear, definite sensation is aroused. E marks an ink ring around the point. Search is similarly made for a definite touch spot on the wrist and on the palm of the hand; a ring is placed around each.

2. *Procedure proper.* S is seated comfortably at table with eyes closed and forearm resting on table. E takes the most flexible hair of the scale and presses it down on the touch spot located on the forearm, and S says "There" if touch sensation is aroused — which is highly improbable with this high degree of flexibility. Use the same hair in touching the spot found on the wrist and the one on the palm. In every case hold the hair perpendicular to the surface and press down firmly and steadily until it begins to bend. E now takes the hair with the next lower degree of flexibility, as indicated by the milligram weight, and applies it to the same touch spots on the forearm, the wrist, and the palm. This order must be strictly followed to avoid fatigue and effects of summation; only a single pressure is made at a time on each touch point in question. As soon as the palm has been touched the round is begun over again with a hair of the next lower degree of flexibility. The chances are that S will first respond "There" when the palm is stimulated. If so, E records the flexibility of the hair in milligrams and continues to apply, in turn, only to forearm and to wrist hairs of less and less flexibility. When the forearm only remains, the applications of the hairs should be made at 45-second intervals to avoid fatigue and the effect of summation. Three records of threshold intensity in terms of milligrams are now entered. At a later sitting, using the same

touch values, the same spots should be investigated in the same order to obtain a set of check results.

NOTE. It is not advisable to apply the hairs in the reverse order, that is, increasing flexibility, owing to fatigue and the persistence of after-images in the touch spots. (E should take the hair that gave no response to the three tested and apply it to the lips and the tip of the nose.)

Results. Experimenter's report. Show the first and the check results and the average of the two for each of the three points tested; thus:

TABLE IX. COMPARATIVE AMOUNT OF JUST OBSERVABLE TOUCH STIMULUS

	PALM	WRIST	FOREARM
First results	---- mg.	---- mg.	---- mg.
Check results	---- mg.	---- mg.	---- mg.
Average	---- mg.	---- mg.	---- mg.

Discussion of results. What other kinds of apparatus do you find in standard texts for determining threshold stimulation for touch? Do your results approximately agree with those found in the texts? What are the sources of error in this experiment? Suggest means for reducing the error to a minimum. Do your results show a law for stimulus threshold of touch when the threshold values for the three points tested are compared?

Inference. Give a law of absolute sensitiveness to touch.

READINGS. 10: 365; 20: 927.

EXPERIMENT 16. To map Touch Spots on Back of Hand (Two Students)

Material. The less flexible bristles with holders used in Experiment 15; scissors; reading-glass; square-centimeter rubber stamp; cross-section paper.

Procedure. S places clenched hand on table, dorsal side up, and E marks off with the rubber stamp a square centimeter on the interosseous space between the second and third metacarpals. E locates with the reading-glass the hairs on S's hand and makes a map of them on cross-section paper. As the hairs are located and mapped, they are cut away with the scissors. E now applies the bristles to each square millimeter, skipping none, along one side of the square. Apply the bristles firmly and steadily and hold them vertical to the surface. S says "There" when a clear sensation is

felt, and E at once makes a dot at the point on the map on the cross-section paper which corresponds to the point stimulated. When one row of square millimeters has been tested, the next parallel line is examined; this is continued until the whole square has been worked over. After an interval of twenty minutes, the square is worked over again by following the lines in the opposite direction; a second map is made from the results obtained for this test.

Results. *Subject's report.* Do the touch spots appear to have size? If so, what is the shape? Are they of the same apparent depth and of the same degree of vividness? Did the stimulus arouse other sensations, and if so, what?

Experimenter's report. Show the two original maps and a third map made from combining the results of the other two. In the third map indicate by crosses touch points of exceeding vividness as indicated by S's report. Indicate by circles any pain points that were discovered.

Inference. Work out your discussion and inference as usual.

READINGS. **16** Part I: 10; Part II: 4–5; **20**: 921–924; **23**: 58–60.

EXPERIMENT 17. **To study Inhibition of Pressure (One Student)**

Material. Small dish containing mercury to the depth of 5 cm.; 3-gallon bucket of water at 20° C.

Procedure. S dips forefinger slowly into the dish of mercury and observes the pressure sensation; he then moves his finger about in the mercury and observes the effects. S next submerges his arm in the water and observes the sensations.

Results. *Subject's report.* Where was the pressure felt on the forefinger in the mercury? Did the sensation of pressure increase with the depth in the mercury? Was there any increase in intensity as the arm was submerged in the water? Where was the sensation of pressure felt on the arm?

Discussion of results. Explain how contrast enters into this experiment. Why do we not feel atmospheric pressure?

Inference. ------------------------------------

EXPERIMENT 18. **To study Exhaustion of Touch (Two Students)**

Material. Bristle with pressure capacity not exceeding 30 mg. set in holder as for touch spots.

Procedure. E finds a touch spot on the back of S's hand and touches it regularly every two seconds. S, with eyes closed, makes a

sign every time he feels a touch. After a short time S will be unable to feel the touch.

Results. Subject's report. Was there a gradual decrease in intensity of sensation or a sudden cessation?

Experimenter's report. Give the number of stimulations necessary to exhaust the touch point.

Inference. Work out your discussion and inference as usual.

EXPERIMENT 19. To make a Summation of Touch Stimulus (Two Students)

Material. Bristle with pressure capacity of not more than 2 mg. set in holder.

Procedure. E finds a spot on the back of S's hand where two or more furrows meet. He takes a bristle fine enough to give no sensation when pressed until it bends slightly. S closes his eyes and E applies the bristle until S gives the signal that he has felt a touch sensation. The bristle must always come down on its end and on exactly the same spot on the skin, stimulations being given rapidly every two or three seconds.

Results. Subject's report. Is this sensation different from that produced by a single stimulus?

Experimenter's report. What is the number of stimulations necessary to produce sensation?

Discussion of results. Can you suggest how these physiological effects are summed up, in the end organ of touch, or in the brain, or are both equally involved?

Inference. What law has been illustrated?

EXPERIMENT 20. To determine the Space Threshold of Touch Discrimination: Weber's Sensory Circles (Two Students)

Material. Franz's simple double-point æsthesiometers; drawing paper; prepared tables.

A simple instrument sufficient for the purposes of this experiment may be made by cutting two narrow strips from light tin about 8 cm. long, narrowing one end of each to a rounded, smoothed point, and riveting the large ends together, using it in connection with a millimeter scale.

Procedure. Draw in ink on the palm of the hand, the middle part of the forearm, and the back of the neck two lines, about 50 mm. in length, bisecting each other at right angles, one lying along the

longitudinal and one along the transverse axis of the part in question. The æsthesiometer is to be applied along these lines. S lays his forearm on the table, volar side up, and closes his eyes. E applies the æsthesiometer to the prepared parts, taking care that the points touch the surface simultaneously and that the pressure used is just sufficient to give a well-defined sensation of contact. A few preliminary trials are made to determine roughly (1) the smallest distance apart possible for the points to be clearly perceived as two, and (2) the greatest separation which will permit the perception of two points as one. This will suggest roughly the limits within which the experimental series will fall.

Beginning on the palm with a distance between the points which will give two clearly perceived sensations, E makes a series of trials, decreasing the distance between the points until S calls out "One." This distance is recorded as the just unnoticeable distance.

The just noticeable distance is obtained by starting with the points so near together that only one sensation is felt and increasing the distance until S calls out "Two." Five determinations are made of the just unnoticeable and of the just noticeable distances in both lengthwise and crosswise directions on the three parts of the body mentioned above, and the results are recorded in the tables which have been prepared.

Cautions. 1. S must keep the eyes closed and give great care to making accurate responses. S should not know his results.

2. E must be careful to have the two points touch the skin simultaneously and with equal pressure, — the least necessary to produce a touch sensation.

3. Above all, the skin must not be fatigued. This may be avoided by going from one part of the body to another when E notices results which may indicate fatigue.

4. Sometimes one point alone should be used.

Results. *Experimenter's report.* Make tables with averages for every column. The arrangement in Table X is suggested.

Sensory circles. The sensory circles are constructed for each part studied by taking as the vertical diameter the average of the just unnoticeable and the just noticeable *lengthwise* distances (why?) and for the *crosswise* diameter the average of the like distances in the crosswise direction. The three circles, — for the palm, forearm, and back of neck, — drawn accurately on drawing paper according to the experimental measurements, form an objective representation of the relative touch-discrimination thresholds in the lengthwise and crosswise directions.

TABLE X. SPACE THRESHOLD FOR TOUCH DISCRIMINATION

Trial	Palm		Forearm		Neck	
	Lengthwise	Crosswise	Lengthwise	Crosswise	Lengthwise	Crosswise
I. JUST UNNOTICEABLE DISTANCE						
1						
2						
3						
4						
5						
Average						
II. JUST NOTICEABLE DISTANCE						
1						
2						
3						
4						
5						
Average						
Average of just unnoticeable and just noticeable						

Discussion of results. On which part is the finest discrimination found? Where the least fine? Is discrimination better lengthwise or crosswise? Explain. Explain the meaning of the sensory circles. Which is shorter, the just noticeable or the just unnoticeable distance? Why?

Why are the just noticeable and the just unnoticeable differences averaged to obtain the space threshold? (23: 187) Why should S be kept in complete ignorance of his judgments? Are there any results of practice? Are any double perceptions of single-point stimulations noted by E? How are they explained? What changes in results might be expected if the touch stimulus were applied to the tip of the finger? to the lips? to the upper arm? Explain what is meant by the threshold of sensory discrimination. What definite law can be obtained from this experiment? What is preperception here? Does it form an error? Does this error tend to reënforce or cancel the error of expectancy? Can you give examples of other fusions of sensations?

Inference. State the law of space-threshold discrimination.

READINGS. **4**: 152–153; **6**: 284–285; **9**: 337–340; **10**: 396–402; **13**: 216–219; **20**: 928–933; **21**: 74–81; **23**: 186–194; **25**: 160–162.

THE TEMPERATURE SENSES

EXPERIMENT 21. To locate Cold and Warm Regions on the Face (Two Students)

Material. Nails kept warm (40° C.) in hot sand; nails cooled by snow or ice water; drawing paper.

Procedure. All students prepare for use, on drawing paper, a large diagram of the face with two parallel lines about an inch apart inclosing an area extending in circular fashion over the forehead, just above the eyebrows, over the cheek bones, and across the chin. E marks out a similar area on S's face with soft pencil. Then, beginning at the center of the forehead, with a cold nail wiped dry he explores this area with a slow and uniform motion and not too heavy pressure, holding the nail at right angles to the face. S indicates when the cold sensation is felt, and E marks down on the diagram tiny circles (O) in the cold areas. Several tracings should be made within the marked region, but the same part should not be gone over twice. E and S exchange places, and the process is repeated.

The same procedure is gone through with warm nails. The warm nails should be decidedly warm (about 40° C.) but not hot. The warm areas are indicated by tiny cross marks (X).

Caution. Neither cold nor warm nails should be used long, a fresh one being chosen before the temperature changes to any extent.

Results obtained here roughly indicate warm and cold areas. For more accurate work consult **23**: 57–60, or other standard works.

Results. Represent results by a diagram of the face bearing the symbols O and X, respectively, showing the relative positions and frequency of the two regions.

Discussion of results. Are cold or warm spots more numerous? Can you find any spot responding with the same sensation to warm and cold nails? (See **26**: 198 — paradoxical cold sensation.) Which regions are more difficult to locate, warm or cold? Which are more sharply localized (definite)? What are the temperature sense organs?

Inference. State the law of distribution of temperature regions.

READINGS. **10**: 344–345; **19** Part I: 7; **20**: 945–965; **21**: 82–85; **25**: 158–159.

Experiment 22. To observe Temperature Adaptation (One Student)

The purpose of this experiment is to show how the body becomes adapted to temperature conditions, so that the sensation of warmth or cold is not a measure of temperature, but of difference in temperature between the body and its surroundings.

Material. Large vessel of water at 10° C. and one at 18° C.; two thermometers; ice.

Procedure. Hold the hand for one minute in the vessel of water at 10° C., then transfer it to that at 18° C., holding it here until the sensation becomes constant.

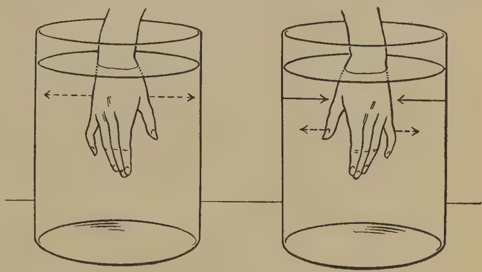

Fig 5. Flow of heat in adaptation

Note. For this and the following experiment monitors may be appointed to keep the water in the various vessels at the required temperature, making the experiment a coöperative one. The thermometers must be observed every four minutes and the temperature kept constant by the addition of ice or hot water as needed.

Results. Make diagrams indicating the flow of heat.

Subject's report. What sensations are felt in the first case? What initial and what final sensations are felt in the last case?

Discussion of results. Explain the opposite thermal sensations. How is contrast illustrated here? How is adaptation illustrated?

Inference. State the law of adaptation to temperature.

Readings. **10**: 347; **12**: 66–67; **19**: 10.

Experiment 23. To find the Physiological Zero (One Student)

Material. Three vessels, each containing about one gallon of water with temperatures respectively 20° C., 30° C., and 40° C.; ice and hot water; stop watch or clock.

Procedure. S puts three fingers of one hand into water at 20° C., three fingers of the other hand into water at 40° C. After they have been held for forty-five seconds in the same position, both sets of fingers are transferred into the water at 30° C.

Results. Make diagrams of the hands in the three vessels, indicating the flow of heat by arrows, as shown in Fig. 6.

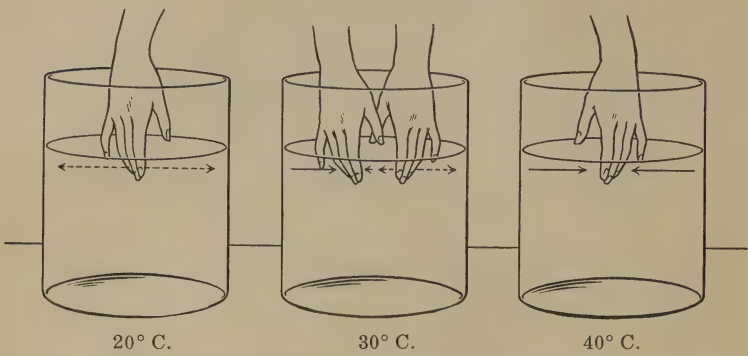

FIG. 6. Flow of heat in producing physiological zero

That degree of temperature which excites no sensation of heat or cold is called the physiological zero. Usually it is the normal body temperature.

Discussion of results. Explain the shifting of the physiological zero in the three cases, showing how the experiment illustrates adaptation. How is contrast illustrated here? Why should one always regulate room temperature by a thermometer rather than by one's feelings? Why does one feel uncomfortably cold on going from a warm room into the cold air? Explain later sensations. Give three other common examples of this principle. Upon what does the effect of a thermal stimulus depend?

Inference. Give as inference the law of shifting of the physiological zero.

READINGS. 4: 98; 10: 366; 17: 70; 19: 9.

KINÆSTHETIC SENSES

These senses produce awareness of movement, of resistance, of strain, and of bodily position (equilibration sense). The sense organs are in the striped muscles, the tendons, the joint surfaces, and the joint capsules. The rôle of these senses in the perception of weight, of space, and of rhythm forms one of the most important sets of problems in psychology. Their

presence is not so striking and compelling as that of eye, ear, taste, etc., and on that account they command but little attention in ordinary life.

EXPERIMENT 24. To discover the Threshold Stimulus for Weight (Two Students)

Material. Finger stall for index or middle finger with a fine silk thread 30 cm. long attached to the tip end; pin bent like a fish hook fastened by its head to the farther end of the string; nine beads weighing respectively 2, 3, 4, 5, 6, 7, 8, 9, 10 g.; piece of cloth 8 in. by 10 in. Beads weighing from 7 to 10 g. may be trimmed from lead and pierced with a hole.

Procedure. S places the stall on the index finger and rests the arm comfortably on the table; the palm is up and projects over the edge of the table; the string to the stall is slack with the pin hook lying on the cloth supported by a chair. E places the 2-gram bead on the pin hook and requires S to raise finger and hand, bending from the wrist, through an arc of about 35 degrees and then slowly to lower the hand to the table. It is important that the rate of raising and lowering should be slow and uniform. S responds "yes" if a weight is felt, "no" if it is not felt. Repeated up-and-down movements are not allowed in sensing a weight. As a check require S to raise the hand with no bead on pin. Try next successively the 3-gram weight, the 4-gram weight, the 5-gram weight, and so on until S, being sure that the weight has been sensed, answers "yes." (S should know the direction in which the weight is changing.) Call the weight first sensed *stimulus threshold weight increasing*. E now reverses the process and begins with the 10-gram weight. S answers "yes" at each lift. The procedure continues with the 9-gram weight, 8-gram weight, and so on down until S responds "no." Call the last weight unsensed *stimulus threshold weight decreasing*. Repeat both series once more, observing the same precautions throughout.

Results. *Experimenter's report.* Make this in tabular form, showing the weight in grams for both ascending and descending series. Average of four trials is the stimulus threshold for lifted weights.

Discussion of results. What error is caused by knowing in which direction the weight is being changed? What condition in the experiment produces preperception? What error is caused by the

fact of preperception? For the relation between the error of expectancy and that of preperception, see the discussion of Experiment 20.

Inference. Include in your inference the definition of stimulus threshold for weight and the result obtained.

READINGS. **4**: 154; **16**: 192–197, 241; **19**: 344–349.

EXPERIMENT 25. To study the Effect of Rate, of Space, and of Order on Sense of Resistance (Sensations to "Lifted Weights") (Two Students)

Material. Two support rods; string 2 ft. long; metronome; a weight of 1 kg. or sad-iron with holder; three weights of same size and shape, two weighing 90 g. each and the third, 92 g.

Procedure. 1. In all lifting grasp the weight between the thumb and first and second finger and lift from the shoulder. Lift the 1-kilogram weight twice, lifting it first to a height of 12 in. at the most natural and convenient rate, and the second time very slowly, beginning with less than the necessary effort and gradually increasing it until the weight rises and is lifted to the former height. Compare the weights for the two trials. E keeps the record.

2. Tie the string to the support rods at a height of 12 in. above the table in order to control the height of the lift and raise the 90-gram weight until the wrist touches the string, allowing four seconds for raising and lowering the weight. Then raise the weight to a height of 6 in., allowing four seconds as before. E records S's judgments.

3. S is seated squarely in front of a table. Two weights of 90 g. each are placed side by side and 4 in. apart on the table in front of S. S lifts first the weight on his left with his right hand to a convenient height and at a natural rate and then the other in the same way with the same hand and compares the weight of the second with the weight of the first, saying "Lighter," "Equal," or "Heavier." Repeat twice. S now lifts the weights in the same order with the left hand, always comparing the second with the first. The same procedure is used with a 92-gram weight. Three trials are made.

Results. Experimenter's report. Show S's judgments in brief form as follows: A weight lifted slowly is _ _ _ _ _ than when lifted _ _ _ _ _. A weight lifted a short height is _ _ _ _ _ than when lifted higher. A compared weight equal or slightly heavier than a standard weight is judged _ _ _ _ _ than the standard weight.

Inference. Summarize your results in a general statement.

READINGS. **16**: Part I, 206; **19**: 26–27.

EXPERIMENT 26. **To study the Sense of Resistance (Two Students)**

Material. Rubber band about $\frac{1}{2}$ in. wide; string; heavy weight; small rod; small box of sand or sawdust.

Procedure. 1. Grasp the ends of the rubber band firmly between the thumb and index finger of each hand; stretch the rubber its full length and then allow it slowly to return to normal slackness. Observe the sensation that occurs just as the elasticity of the rubber ceases to pull.

2. Tie one end of the string to the weight and the other end to the small rod (S should not know the length of the string). E places the rod in S's hand, and he then lowers the weight slowly and at a uniform rate until all the weight rests on the sand. It requires close observation to sense the resistance, but when once sensed, it is unmistakable.

Results. *Subject's report.* State where the resistance is located in both responses, 1 and 2. Where are the sense organs of resistance located?

Inference. State the law of projecting touch sensations.

READINGS. 4: 102; 19: 26–27, 33–34; 20: 1012–1018, 1021, 1024.

EXPERIMENT 27. **To determine the Stimulus Difference Threshold for Lifted Weights (Two Students)**

Material. Three sets of nine weights each, uniform in size and shape; support rods; screen curtain; prepared tables, two for each set of weights.

The weights of each set form a consecutive series differing by a 1-gram increment. The mean weights, two for each set, of the three sets, form a geometrical progression (for example, 16, 32, 64). Boxes for weights may be made from paper tubes, 1 in. in diameter, the bottoms being made from adding-machine paper and the tops sealed over with tissue paper.

Procedure. E and S are seated on opposite sides of a small table with screen curtain between them. Set the standard (or mean) weight on a cross mark on a sheet of paper in front of S. The compared weight is always placed on the same side of the standard. Both weights, standard and compared, must be lifted to the same height and at the same rate. Stretch a string above S's wrist to control height. For rate, one second for lifting and one second for lowering has been recommended. Time for presenting the compared

weight and recording S's judgment may be from three to four seconds. The rate adopted should be kept as uniform as possible. E plans beforehand the manner for presenting the weights. As there are an equal number of weights above and below the standard, four possible orders exist: (1) above standard, decreasing to standard; (2) below standard, increasing to standard (represent the order thus: ⟶ S. ⟵); (3) from standard, increasing; and (4) from standard, decreasing (represent the order thus: ⟵ S. ⟶). Assuming that the first or second order is used, E begins by placing the heaviest or lightest weight beside the standard. S lifts first the standard and then the weight to be compared and judges whether the second of the pair is heavier, lighter, or equal. E continues to present the weights in pairs, consisting of standard and each weight in sequence, until S fails to sense a difference between the standard and compared weights. E records *only* when the judgment is "equal" (using sign "="). Present the standard first in half of the trials; but in the other half, when it is presented second, the judgment must always refer to the compared weight. Now and then repeat with the same weight and also with the extra standard, but make no record of judgments. Continue until ten judgments of "equal" are entered above and below the standard. The procedure is now repeated, with the difference that E uses the third or fourth order and begins with the standard weight and the one next above or below and continues until S replies "Greater" (sign "+") or "Less" (sign "−"). Entries in table to right of standard, or above standard, will be "+." At the left of standard they will be "−." Now continue the experiment with the next higher set of weights — for example, mean 36 g. — observing the same conditions as outlined above. Use of the third set had better be postponed to a later sitting to avoid fatigue.

Results. *Experimenter's report.* This should show six tables after the three sets of weights have been used and three general summaries, one summary for two tables having results of the same set of weights. Table XI and summaries of two tables show sample results.

Discussion of results. The average, 2.4 g., is the threshold of difference when the 16-gram weight is used as a standard. The ratio of 2.4 to 16 is approximately 1/7. This ratio should be compared, of course, with those obtained when using the 32-gram and the 64-gram weights, respectively, as standards under the same conditions. These ratios should show a constant relation and as such would demonstrate Weber's law for lifted weights. Consult the readings given below or other methods of using lifted weights to demonstrate the law.

TABLE XI. RECORD OF JUDGMENTS OF EQUAL LIFTED WEIGHTS
Plan: ⟶ S. ⟵

NUMBER OF TRIALS	WEIGHT IN GRAMS								
	12	13	14	15	S. 16	17	18	19	20
1				=		=			
2		=						=	
3				=			=		
4				=		=			
5			=			=			
6		=					=		
7			=			=			
8			=				=		
9			=			=			
10				=		=			
Total judgments		2	4	4		6	3	1	

AVERAGE BELOW S.

F.[1] D.[1]

$4 \times 1 = 4$ g.
$4 \times 2 = 8$ g.
$2 \times 3 = \underline{6}$ g.
18 g.
Average = 1.8 g.

AVERAGE ABOVE S.

F. D.

$6 \times 1 = 6$ g.
$3 \times 2 = 6$ g.
$1 \times 3 = \underline{3}$ g.
15 g.
Average = 1.5 g.

1. Average of weights not perceptibly greater than standard = 1.5 g.
2. Average of weights not perceptibly less than standard = 1.8 g.
3. Average of weights just perceptibly less than standard = 3.4 g.
4. Average of weights just perceptibly greater than standard = 3.2 g.

9.9 g.
Average = 2.4 g.

Inference. Let your inference be a statement of the law based upon the results of your own work.

READINGS. 4: 124–125; 10: 363–364; 20: 1022–1024.

EXPERIMENT 28. To study Motor Attunement (One Student)

Material. Three weights: No. 1, a weight of 650 g.; No. 2, a weight of 850 g.; and No. 3, a weight of 2 kg.

Procedure. Lift the heavier of the two small weights, 850 g., with the left hand, and the lighter, 650 g., with the right hand, observing the difference in weight. Now lift with the left hand the

[1] F. = frequency; D. = amount of difference in grams.

2-kilogram weight twenty-five times. At the twenty-sixth lift change to weight No. 2 and lift with the left hand. Then with the right hand lift weight No. 1. At once compare weight No. 2 with weight No. 1 under the conditions of the final lifting.

Results. Subject's report. State the rate at which the heavier (weight No. 2) of the two compared weights was lifted. Also state its weight compared with weight No. 1.

Discussion of results. Several factors may conspire to produce attunement. E. C. Sanford observes that "by practice the nervous centres discharging into the muscles that raise the 2 kg. weight become accustomed to a larger discharge than that required for the small weight, and do not at once re-adapt themselves, but supply too great a discharge: hence the weight rises with greater rapidity and consequently is pronounced lighter."

Inference. What is the meaning of motor attunement?

READINGS. 16 Part I: 207–213; 19: 27.

EXPERIMENT 29. To determine the Stimulus Threshold of Movement (Two Students)

Material. Arm board for the forearm and hand, hinged and counterbalanced as shown in Fig. 7; a millimeter scale is attached to the upright for use in reading the arc of movement.

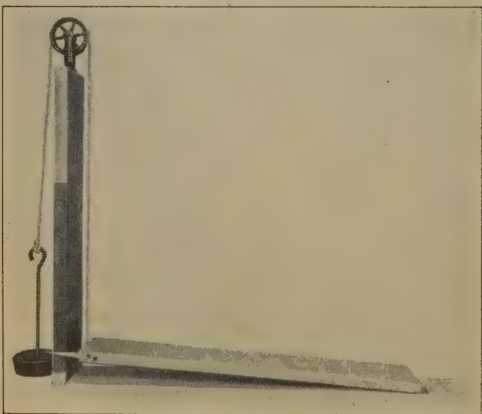

FIG. 7. Apparatus for stimulus threshold of movement

Procedure. S places his relaxed arm and hand on the arm board and closes his eyes. E very slowly and uniformly raises or lowers the free end of the arm board by pressing down or lifting the counterbalance. S says "There" as soon as movement is sensed. E observes and records the reading of the pointer just as S signals. S must be careful not to mistake the sensation of increased pressure or of jar for that of movement. Make twenty trials.

Repeat the procedure, this time E moving the counterbalance rather rapidly but without jerks. Make twenty trials. Uniformity of rate is very essential.

Results. Subject's report. Where was the sense of movement chiefly located? Do the readings in millimeters, taken at the signals, contain an error? If so, in what direction?

Experimenter's report. Show the results in the form of a table, as in Table XII. Sample results given here are only approximations. What errors are involved in the use of such an apparatus?

Inference. ____

READINGS. 4: 119; 10: 364; 22: 357.

TABLE XII. STIMULUS THRESHOLD OF MOVEMENT

SLOW SERIES	FAST SERIES
F.[1] D.[1]	F. D.
1 × 3 = 3	2 × 3 = 6
4 × 4 = 16	3 × 4 = 12
2 × 5 = 10	7 × 5 = 35
4 × 6 = 24	4 × 6 = 24
2 × 7 = 14	1 × 7 = 7
3 × 8 = 24	2 × 8 = 16
2 × 10 = 20	2 × 8 = 16
1 × 11 = 11	1 × 10 = 10
1 × 12 = 12	
Average = 6.7	Average = 5.5

EXPERIMENT 30. To determine the Threshold of Difference: Active Movement. Method of Average Error (Two Students)

Material. The same as in Experiment 29.

Procedure. Use two distances, 10 cm. and 20 cm., respectively, for the standard distances of movement. Let a trial consist in making (1) a standard movement (for example, 10 cm.) and (2) a movement which S feels to be just less or just greater than the standard. E sets the pointer of the arm board at a convenient starting-point. S closes his eyes and makes the standard movement, always starting from the same point. E stops the arm board when the pointer indicates that the standard has been given. The pointer is again set at the starting-point, and S now attempts to make a movement greater or less than the standard. S aims to make the second move-

[1] F. = frequency; D. = distance in millimeters.

ment greater in one half the cases and less in one half. Make fifty trials for each of the standards, 10 cm. and 20 cm.

Results. *Experimenter's report.* Show a frequency distribution of errors in tabular form, giving errors greater and those less than the two respective standards.

Discussion of results. What number indicates the threshold for active movement? Compare it with the threshold for passive movement as determined in Experiment 31. Account for the direction of the difference.

Inference. ----------------------------------

READING. 20: 1016–1017.

EXPERIMENT 31. To determine the Threshold of Difference: Passive Movement (Two Students)

Material. The same as in Experiment 29.

Procedure. E uses two standard distances of movement for S's passive arm. Let the smaller standard distance be 10 cm. and the three longer distances to be compared be increased by increments of 2 mm. and the three shorter distances be decreased by the same increments, that is, 4–6–8–10–12–14–16. Let the distance for the longer standard be 20 cm., with the three longer distances and the three shorter distances in series of 3-mm. increments, respectively, as follows: 11–14–17–20–23–26–29. E makes the standard movement first, then follows with the movement to be compared. S judges the second movement as equal, greater, or less than the standard. E records only when the judgment is "equal" (using sign "="). Let the order of presenting the standard follow that outlined in Experiment 27 for lifted weights: that is, begin (1) above standard, decreasing to standard; (2) below standard, increasing to standard; (3) from standard, increasing above; (4) from standard, decreasing below. Continue with *first* and *second* orders, as in Experiment 27, until ten judgments of "equal" are entered above and below the standard. Repeat the procedure, with the difference that E uses the *third* or *fourth* order. S replies "Greater" or "Less." Entries in the table above standard will be "+," and below standard "−." Proceed similarly with the larger standard, 20 cm.

Results. *Experimenter's report.* Arrange this in tables and summaries similar to those used for the threshold of lifted weights (Experiment 27).

READING. 20: 1014–1015.

SOUND

EXPERIMENT 32. To determine the Threshold Stimulus of Sound. Method of Minimal Change (Two Students)

NOTE. This experiment can be performed only in a quiet room.

Material. Acoumeter (Lehmann's); steel ball of known weight less than a gram; tape line; chair.

The essential parts of this acoumeter are shown in Fig. 8. The millimeter screw *S* is provided with two heads *H* divided into

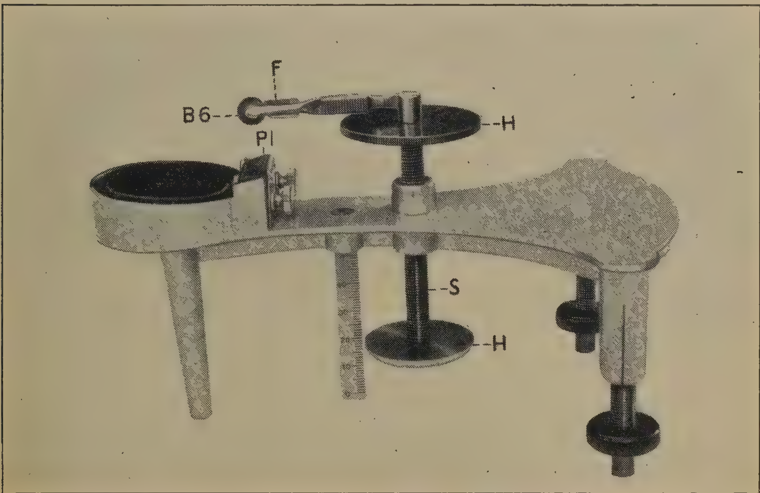

FIG. 8. Lehmann's acoumeter, for determining threshold stimulus to sound *S*, millimeter screw; *H*, screw heads; *F*, forceps; *Pl*, metal plate; *B 6*, steel ball

quadrants; those of the upper head coincide by number with those of the lower; a turn through a quadrant changes the height of the forceps *F* 0.25 mm.; a complete turn changes it 1 mm. The distance of the fall of the steel ball to the metal plate *Pl*, producing the sound stimulus, is measured on the millimeter scale beneath the base. The jaws of the forceps are slightly concave and corrugated to hold the ball securely.

Procedure. 1. *Preliminary.* S sits at a distance of 10 m. from the acoumeter with the unused ear plugged and eyes closed. E roughly

determines by trial the distance of fall at which a sound is observable, usually about 2 mm. for a normal ear at a distance of 10 m.

2. *Procedure proper.* E now makes two series of observations, ten ascending and ten descending. In the first series start with a height near zero and increase it by increments of 0.25 mm. E signals "Ready" and one second later releases the ball; at times the release is not made, as a check against S's responses. S responds "no" when stimulus is not heard and "yes" when audible. The height giving the first audible sound is recorded in millimeters under the column "Ascending Series" in the table which has been prepared. For the descending series the forceps are adjusted to the roughly determined height in the preliminary trial and the distance decreased by 0.25-millimeter increments until S responds "no." Record this distance under column "Descending Series." E takes care not to release the ball at times. After performing one half of each series E and S should exchange places.

Results. Experimenter's report. Make the report in tabular form and show twenty determinations. A sample table (Table XIII) is here given, showing results of a normal ear. Note that the average in millimeters for the twenty trials is multiplied by the weight of the ball, 0.4 g.

TABLE XIII. RESULTS OF RESPONSES TO STIMULUS THRESHOLD FOR SOUND

Trial	Ascending Series (Millimeters)	Descending Series (Millimeters)
1	2.00	1.50
2	2.25	2.00
3	2.50	1.75
4	2.25	1.50
5	1.75	1.25
6	1.75	1.50
7	2.25	1.75
8	2.75	1.50
9	2.00	1.50
10	1.75	1.75
	Average, 2.13	Average, 1.6

$$\text{Final average} = \frac{2.13 + 1.6}{2} = 1.86 \text{ mm.}$$

Stimulus threshold for sound = 1.86 × 0.4 g. = 0.744 g.-mm.[1]

[1] The real stimulus in this case, of course, is the air vibrations caused by the impact of the ball falling on the metal plate. Symbol g.-mm. is to be read "gram-millimeter."

Discussion of results. Do your results show evidence of improvement with practice; that is, increased sensitivity? Do the results show that you made false responses? If so, account for them. Account for the fact that you noted distracting sounds more readily with the progress of the work. Find in the reading given below other methods for determining the stimulus threshold for sound.

Inference. State your threshold and class average.

READING. 10: 367–369.

EXPERIMENT 33. **To study Adaptation of Sound (Two Students)**

Material. Soft rubber tube 1 m. in length and 6 mm. to 8 mm. in diameter; tuning-fork.

Procedure. S places one end of the rubber tube in the left ear and the other end in the right ear. Support the tube at its mid-point on a rod or loosely in a clamp. E strikes the fork and then places the stem upon a point in the tube at which the sound is equally intense in the two ears. Again holding the fork on this place, E pinches the tube on one side, thus shutting the sound from the ear on that side. Hold the fork in this position until the sound becomes rather faint. E releases the tube and S notes on which side the sound is stronger and where it is localized.

Results. Record observations as to location and strength of sounds under the different conditions. Explain the fact of adaptation in this experiment. What is suggested about the localization of sounds?

Inference. State what is meant by adaptation in the field of sound.

EXPERIMENT 34. **To study Summation of Sound (Two Students)**

Material. Low-pitched tuning-fork; rubber tube 1 m. in length.

Procedure. S places the ends of the rubber tubing in his ears, and E places the tuning-fork, sounding as faintly as possible, on the middle of the tubing.

Results. Observe that the sound does not reach its maximum intensity at once. To what tendency of the auditory mechanism is this fact of summation due?

EXPERIMENT 35. **To observe Harmony of Sound (Two Students)**

Material. Tuning-forks, c', e', g', and c'',[1] mounted on resonance boxes; rubber hammer.

[1] The symbol c' designates middle c of the scientific musical scale, so called. A tuning-fork with a pitch of c' has a vibration rate, *vs*, of 256 per second. An e' fork has 320 *vs*, a g' fork has 384 *vs*, and a c'' fork has 512 *vs*, the octave above c.

Procedure. S stands in front of the forks and E strikes c' and c'', using as nearly as possible the same intensity. S listens carefully to see whether he can hear the two tones. The lower fork is silenced and the effect noted. The same is done with c' and g' and with c' and e'.

Results. State in which of the intervals the component sounds are heard most distinctly; in which they are heard least distinctly. Describe the fusions as nearly as you can. Is there summation of intensities? Has the resulting chord a new quality? Do pitches fuse or harmonize? What is the difference between fusion and harmony?

THE VISUAL SENSE

It is believed that the laws of color mixture and the fundamental principles of color theory may be best understood when the work is done by the individual students in the laboratory. In a course where time is limited, it may become necessary for the instructor to select some work for class demonstration; and probably no part of a course in psychology lends itself so easily to such purposes as the color experiments which may be performed with the electric-motor color-mixer. On the other hand, if individual work is desired, the color top is recommended. This small device is accompanied by color disks with slits ready for use and contains an outer rim which is graduated so that the proportions of mixtures may be read in per cents or in degrees of circumference. The student may work with these in the laboratory, or may verify for himself at home the class demonstration.

Experiment 36. To determine the Threshold Stimulus of Color. Method of Minimal Changes (Two Students)

Material. Color wheel or color top; disks of white, black, red, and blue in two sizes; graduated disk for measuring degrees.

Procedure. E places on the color wheel a large disk of black, a smaller disk for measuring degrees, and over this two smaller disks of black and red, so interlapped that a very minute portion of the red is visible. E and S sit opposite each other at the table, and after the apparatus has been set in motion, E shows it to S. S (who should not know which of the two colors is to be used) judges whether there is any color visible. E then introduces a little more of the color and

so proceeds until S can tell what color is being used, E recording the amount in degrees. Then E begins with the whole red disk and gradually adds black until no red can be perceived, recording the last amount of red visible. The average of these two results is the stimulus threshold for red. The same should be tried for blue. Repeat the experiment, using white disks instead of black.

Results. *Experimenter's report.* Make this in terms of degrees and minutes of circumference.

Inference. Define stimulus threshold for color, and give your results.

READINGS. 2: 113–115; 9: 124–129; 20: 1079–1080; 27: 52–55.

EXPERIMENT 37. To observe the Intensity Difference Threshold for Brightness. Method of Minimal Change (Two Students)

Material. Color wheel; black and white disks of two sizes; disks graduated in degrees and seconds.

Procedure. E places a large black and a large white disk interlapped upon the color wheel and over these a small black and a small white disk interlapped. The disks are adjusted so that in each case 90 degrees of black and 270 degrees of white are exposed. The wheel is revolved and the brightness of the two grays compared. It should be the same. E now adds a very small amount of white to the outer white disk, and S reports whether he sees a difference in brightness between the inner and outer disks. Very small amounts of white are added until S notes a just perceptible difference in brightness, which is recorded.

Starting with the outer disk plainly brighter than the inner, decrease the amount of white until the brightness is apparently the same. The degrees of difference of the white in the inner and outer disks are recorded.

Finally starting with the outer disk plainly darker than the inner, increase the white as above and take the measurement. Make twelve measurements. Repeat, using a standard of 180 degrees.

Results. *Experimenter's report.* Summarize the numerical results as indicated in Table XIV, page 88.

Discussion of results. Explain the difference between the threshold stimulus and the intensity difference threshold. Do your results confirm Weber's psycho-physical law? Explain. Find the average of the results of the class and compare as to confirmation of the law. What are the possibilities of error in your results? In what other ways might you observe the operation of the law in vision?

Inference. See inference for Experiment 36.

Table XIV. Intensity Difference Threshold

Trial	Standard 270 Degrees				Standard 180 Degrees			
	Above Standard		Below Standard		Above Standard		Below Standard	
	Increase White	*Decrease White*	*Decrease White*	*Increase White*	*Increase White*	*Decrease White*	*Decrease White*	*Increase White*
1								
2								
3								
Average								
Final Average	*Threshold of Difference at 270 degrees =*				*Threshold of Difference at 180 degrees =*			

Experiment 38. To observe the Responses of the Retina to the Primary Colors, so called, and to determine the Limits of the Visual Color Field (Two Students)

Material. Perimeter; stimulus cards, 3 in. by 2 in., of black cardboard, bearing about $\frac{1}{2}$ in. above one of the longer edges a disk of colored paper about $\frac{3}{8}$ in. in diameter, a set containing five cards with red, green, blue, yellow, and white disks; piece of mirror glass, 0.8 in. by 0.6 in., mounted on the end of a wood strip 2 in. by .5 in., which may be held in a clamp support, to serve as a fixation point; headrest.

A very satisfactory chin support may be made by removing the hook from a wooden coat hanger and fastening in place of it a wooden rod (a broomstick is excellent) on the convex side. The rod is clamped to a table and the inverted coat hanger forms the chin support (see Fig. 14, p. 114).

Procedure. E sets up the support apparatus and adjusts the fixation mirror to a comfortable height for S. It must be on a level with the eye, and the support must hold the chin so that the line of vision is in a horizontal plane. The eye to be explored sees itself throughout in the mirror. The other eye is closed. S holds the handle *H* of the perimeter (Fig. 9) in one hand and supports the quadrant *Q* with the other so that his eye looks along its edge to the mirror, the line of sight making an angle of 90 degrees with the other edge of the quadrant, along which lies the carriage arm *C.A.* E now places the stimulus card *St.C.* in the slot of the carriage arm and moves the carriage very slowly toward the line of sight, stopping when S calls "There" on the first view of the disk. E reads and records the angle

made by the indicator with the line of vision as the first of the three records to be made. E continues to move the carriage arm in the same direction until S recognizes a color and calls its name. If it is not the color on the disk, E records the color and angle in the second place, and proceeds until the true color is called, recording that in the third place. For some colors the responses in the second and third places in the table are the same. Records 1, 2, and 3 form one trial for that disk. Make three trials with each of the four colors, and as a check use the white disk occasionally. Investigate the horizontal plane (1) on the temporal side of the head, (2) on the nasal side; and investigate the vertical plane (1) above the level of vision down to the visual plane, and (2) below the level of vision up to the visual plane. E should not use the same color disk in any two successive trials in the *same* plane. Why? Average the sum of the trials recorded in the third column for each of the four colors respectively. For the horizontal plane average the trials to right and to left separately, and for the vertical plane average the up trials and the down trials separately. E and S should exchange places from time to time to avoid overfatiguing the eye.

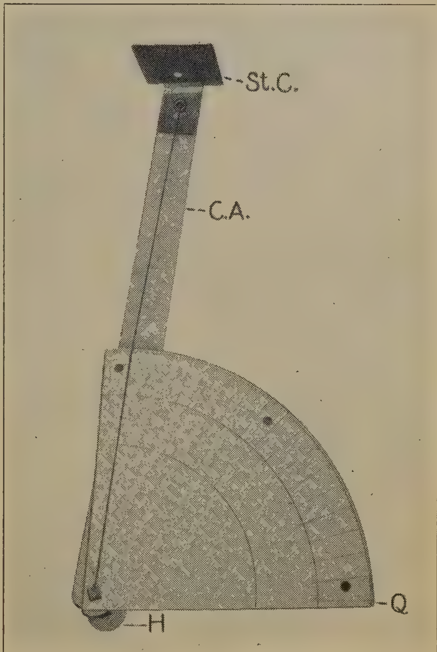

FIG. 9. Perimeter

Q, quadrant; *H*, handle; *C. A.*, carriage arm; *St. C.*, stimulus card

Results. Only E's records are considered in this experiment. These are expressed in two forms: (1) a table of records; (2) a projection map constructed from the results or averages in the table. To construct the map draw nine concentric circles, beginning with a radius of 1 cm. and increasing each succeeding radius by 1 cm. Let 1 cm. on the radii equal one degree of retinal projection. Mark on

the four radii the four points for each color, respectively, as recorded in Table XV. Connect the points for each color to give its color field. A diagram for mapping the visual field is given in Fig. 10.

TABLE XV. RESULTS FOR VISUAL COLOR FIELD: RIGHT EYE

Trial		Blue 1 2 3	Yellow 1 2 3	Red 1 2 3	Green 1 2 3
Horizontal Right	1				
	2				
	3				
	Average				
Horizontal Left	1				
	2				
	3				
	Average				
Vertical Up	1				
	2				
	3				
	Average				
Vertical Down	1				
	2				
	3				
	Average				

Discussion of results. Which is the largest color field in your map? the smallest? Do any of the fields overlap? To what is that due? What color showed the most change in passing from the periphery to the center? What color showed fewest changes? How does your map agree with those found in standard texts? Look steadily at a flower bed or colored carpet or colored wall paper, fixating the center, and tell what the appearance is toward the edge. What connection has been supposed to exist between the three color zones and the evolution of color vision? How may this supposition account for color blindness as it occurs? What is normal color blindness? What color theory do such facts tend to uphold? How can you account for the fact that we are not aware of the three color zones in everyday life? Where is vision clearest? Give an account of the structure of the retina. Would gray or white backgrounds for the disks give different results? Give some practical applications of the principles involved in this experiment; for example, in advertising and window displays.

Inference. Give the color zones in order of their limits.

READINGS. 3: 61–62, 72–73; 4: 74–75; 6: 342; 21: 25–32; 24: 80–83; 26: 210

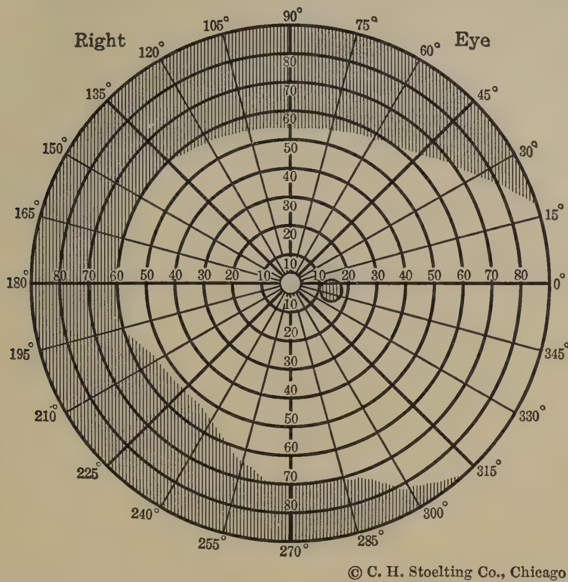

FIG. 10. Diagram for mapping the retinal color field

EXPERIMENT 39. To derive the Laws of Visual After-Images: Negative (Class Experiment)

Material. Stimulus cards 4 in. by 6 in. of white, black, blue, yellow, green, and red (standard colors); backgrounds 8 in. by 10 in. of the same colors; backgrounds 22 in. by 28 in. of white, black, and gray cardboard; clips for fastening; hooks for hanging; metronome; prepared tables, specifying stimulus and after-image backgrounds, etc.

Procedure. The class is arranged in pyramid fashion at a convenient distance in front of the wall or blackboard where the material is exposed. The small stimulus card is hung in front of the class against the wall on the background specified. At a given signal from the instructor (after the "Ready" signal) the class fixates the stimulus card for eight seconds, and at another signal fixates a given point in the projection background. Each student records his results in a prepared table, estimating by the metronome the initial and terminal lag; that is, the time that elapses before the after-image

appears and the time from then until its disappearance. In case the image reappears, that is noted under "Remarks" with the number of such reappearances, clearness, etc.

Results. Experimenter's report. This consists of the following table:

TABLE XVI. RESULTS FOR AFTER-IMAGES

Stimulus			After-Image				
Color or Brightness	Background	Duration (Seconds)	Background	Color or Brightness	Initial Lag (Seconds)	Duration of After-Image	Remarks
White	Black	8	White				
White	Black	8	Black				
White	Black	8	Gray				
Black	White	8	White				
Black	White	8	Black				
Black	White	8	Gray				
Blue	White	8	White				
Yellow	White	8	White				
Red	White	8	White				
Green	White	8	White				
Blue	White	8	Blue				
Blue	White	8	Yellow				
Blue	White	8	Red				
Blue	White	8	Green				
Yellow	White	8	Blue				
Yellow	White	8	Yellow				
Yellow	White	8	Red				
Yellow	White	8	Green				
Red	White	8	Blue				
Red	White	8	Yellow				
Red	White	8	Red				
Red	White	8	Green				
Green	White	8	Blue				
Green	White	8	Yellow				
Green	White	8	Red				
Green	White	8	Green				

Discussion of results. Upon what does the clearness (distinctness) of the image appear to depend? Does the duration of the image vary for the colors and black and white? Compare them. Does the latent period (initial lag) vary for the different colors? What facts of after-images are involved in moving pictures?

Inference. The laws of after-images should answer the following questions. Give complete statements.

1. How does the after-image of a brightness stimulus compare with the stimulus in degree of intensity? Upon what does the effectiveness of the projection background depend? Give example.

2. How is the after-image of a color stimulus projected on a brightness background related to the stimulus? Give example.

3. What effect is produced when the after-image of a color stimulus is projected on a background like the stimulus? Give example.

4. What effect is produced when the after-image of a color stimulus is projected on a background complementary to the stimulus? Give example.

5. What effect is produced when the after-image of a color stimulus is projected on a background neither complementary nor like? Give example.

READINGS. 5: 14–19, 54; 6: 352; 10: 337–338; 20: 1057–1060, 1062–1064; 27: 108–111.

EXPERIMENT 40. To study Visual After-Images: Positive (One Student)

Material. Headrest.

Procedure. 1. S seats himself before a window through which a bright landscape or picture of some kind may be seen. His head is placed in a headrest; his eyes, closely covered with his hands, are turned toward the window. When the dark field is perfectly clear, the hands are quickly removed and immediately replaced without any change in position of head or eyes.

2. In a dark room S looks for a second at a lighted candle, gas flame, or electric light; then covers his eyes and notes the after-image.

Inference. Law of brightness and color for the positive after-images.

EXPERIMENT 41. To study Fusion. Laws of Color Mixture (One Student)

Material. Color top (or wheel if it is to be a class exercise); disks of the various colors (red, blue, green, yellow, orange, violet, black, and white) of two sizes; graduated disk.

Procedure. 1. S, working alone, finds for each of the colors, red, green, blue, and yellow another which will produce gray by mixture. The large disks are used, and when a gray is found which seems

pure, small disks of black and white are fitted over the colored disks and varied until they give a gray that matches the gray obtained from the colors. If there is now any trace of color seen in the original mixture when compared with the pure gray, S tries to remove it by adding a small portion of the other color (either varying the proportions already found or inserting another disk). Amounts used in mixing the colors, both before and after the desired proportion for a gray is obtained, are noted. The exact proportions may be found by using the graduated white disk.

2. Two colors which are not complementary (which do not produce gray) are now mixed — for example, red and yellow, until they produce the best possible orange. The proportions are then noted. The same may be tried with another pair of colors not complementary.

3. Using the four colors red, green, blue, and yellow, three are found which produce gray, and the proportions are noted. Two colors are found which produce gray when mixed with violet, and the proportions are noted.

4. S tries to make a pure gray by using the four colors blue, yellow, red, and green.

Results. The results for parts 1, 2, and 3 are expressed in degrees of color.

Discussion of results. How do Helmholtz and Hering, respectively, explain the phenomena of color mixture? Give Mrs. Ladd-Franklin's evolutionary theory. Are the grays in part 1 all perfect? Are there any colors which have no complementary colors? By using a color top, how can you find colors which harmonize with a given color?

Inference. State the laws of color mixture which you have just demonstrated.

READINGS. **3**: 69–70; **8**: 98–100; **11**: "Vision"; **27**: 87–107.

EXPERIMENT 42 A. **To study Certain Effects of Color and Brightness Contrast (One Student)**

Material. Three cards, 5 in. by 10 in., on which are pasted two 5-inch squares; (1) black-white, (2) blue-yellow, (3) red-green; a strip of tissue paper 5 in. by 10 in; five strips of paper, ½ in. by 10 in., of gray, blue, yellow, red, and green; color wheel; black and white disks of two sizes.

Procedure. 1. S lays the gray strip on the black-white card and covers with tissue paper. He notes the induced effects on the strip; (1) on the black card, (2) on the white card. To measure the amount of the induced intensities, S — first with the color wheel and the

larger black and white disks — produces a gray which just matches the strip, and records the proportions of black and white in the gray. Then with the gray strip on the black-white card covered with tissue paper, he works out with the color wheel and the small disks over the disk just arranged (1) the proportions of black and white in the part of the gray strip on the black background, (2) the proportions of black and white in the part on the white background.

2. S lays the gray strip on the blue-yellow card, covers with tissue paper, and notes the induced effects in both backgrounds. The same is done with the red-green card. On the yellow card he places a gray strip and two inches away a blue strip. He compares them without the tissue paper and again with the tissue covering. S goes through a similar procedure using a yellow strip with a neutral strip on a blue background, then a red strip and a neutral strip on a green background, and then a green strip and a neutral strip on a red background.

Results. 1. For brightness: Record the relative intensities of induced brightness on the gray strip over black and white background respectively. Express the same facts as they are measured in degrees of circumference of the proportional amounts of white and black used in the disks.

2. For color: Describe the induced color effects on the gray strip and on the color strips, respectively.

Discussion of results. Why does the tissue paper enhance the effect? What effect do surroundings have upon colors? How does the artist make use of this principle? Give some contrast effects in everyday life.

Inference. The two principles illustrated above are given in the inference as the chief effects of color contrast.

READINGS. 7 Vol. II: 13–27; **11**: 791–797; **19**: 153–166; **21**: 13–17; **22**: 76–78; **27**: 111–119.

EXPERIMENT 42 B. To study Some Effects of Brightness Contrast (Class Experiment)

Material. Color-mixer; white cardboard; india ink; small brush; compasses; scissors.

To construct a disk similar to the one at the right in Fig. 11, cut from white cardboard a circle 10 in. in diameter. With a compass describe on it four concentric circles, the innermost circle having a radius of 1 in., and increase the radius of each succeeding circle by 1 in. Draw two diameters at right angles and then with a fine brush

spread india ink along the four radii of the two diameters, as indicated by the figure. This disk when rotated forms five concentric circles varying in degrees of brightness.

Procedure. Place the disk on the color-mixer and rotate rapidly. Each circle should be of uniform gray, increasing in darkness toward the center. The disk to the left shows the results of the rotation.

Results. Five concentric brightness circles, increasing in shade from the outer to the inner circle, are formed. It will be observed that any one circle is not of a uniform gray or brightness, yet one would expect it to be uniform, since it is made by the fusion of a

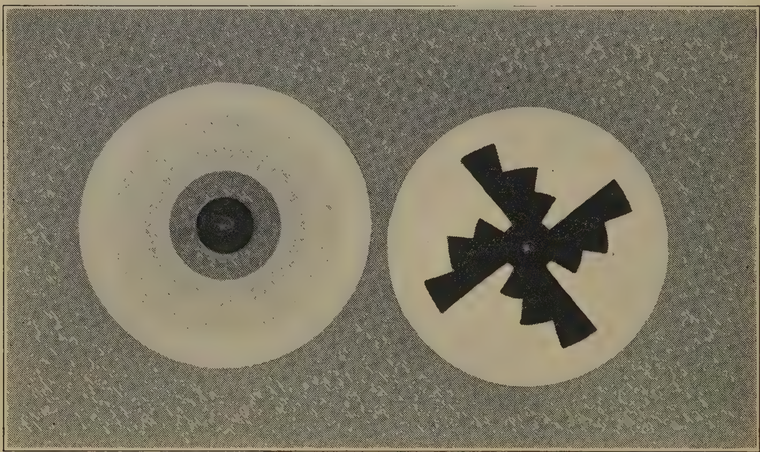

FIG. 11. Disk to show contrast effects in brightness

definite amount of white and black. How does the shade of the outer edge of any one circle compare with that of the inner edge? Of any two adjacent circles the inner one is the darker. What relation, then, exists between contrast effects and differences in light intensities?

Inference. The answer to the last question is the inference for this experiment.

READING. 6 : 353–354.

EXERCISES

1. Show that touch is the sense of "closest motor connections."

2. Which are the "secondary or inferential" senses? Explain, giving examples.

3. What sense is apparently the oldest?

4. What sense, in giving us a "spatial world of things," and in its "immense power of secondary or inferential perception," has become the "business sense of the mental world"?

5. What sense is the only one that can be doubled upon itself?

6. Why are the auditory and tactual reaction times shorter than the visual?

7. Give examples showing that the sense of touch stands high in its power to arouse feelings.

8. Which sense is most attention-compelling?

9. Call to mind your dreams and tell which sense is predominant in your dream world.

10. What sense has most illusions? Why?

11. What explanation do you give for the fact that when a local anæsthetic is given an incision can be made or the organs manipulated in such a way as to seem to necessitate pain and yet the patient will suffer no pain or even the sensation of touch?

12. Why does pressure on the closed eye cause a sensation of light?

13. It has been said that vision is the "queen of the senses." Upon what grounds would you justify that statement?

14. Give examples of after-images you have perceived in other senses than vision.

15. Two men were walking in a forest. A multitude of small insects were producing a sound of very high pitch. To one man the forest was silent, to the other the sound was plainly audible. Account for the difference.

16. Why are yellow and blue registration plates more effective than red and green ones?

17. Why does the psychiatrist, in examining patients, test the acuity of the senses? (Note the necessity for norms in investigations of this kind.)

18. "*The developed mental life is not a matter of immediate sense experiences* but of the representation and manipulation of sensory and linguistic symbols" (E. C. Sanford). In the light of this quotation, explain the rich sense experience expressed in the writings of Helen Keller.

19. Show how window decoration could be made more effective by an application of Experiments 38 and 42A.

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CHAPTER V

ATTITUDE: ATTENTION AND SELECTIVE ACTION

1. For the relation of sensations to activities the term expressional relation or the term attitude will be used. — C. H. JUDD, *Psychology*, p. 134

2. Through stimulation affective and cognitive nature becomes organized into habitual ways of reacting to life, *i.e.*, into attitudes. — E. S. BOGARDUS, *Fundamentals of Social Psychology*, p. 45

3. So numerous and varied are the ramifications of attention, that we find it defined by competent authorities as a state of muscular contraction and adaptation, as a pure mental activity, as an emotion or feeling, and as a change in the clearness of ideas. Each of the definitions can be justified from the facts if we put the chief emphasis now upon one phase and now upon another of its varied expressions. — W. B. PILLSBURY, *Attention*, p. 1

4. The selective effects of attention responses naturally depend upon the particular person who is acting. . . . The selective function of attention has its roots of course in the general stimulational character of objects developed through the historical contact of the person with them. — J. R. KANTOR, *Principles of Psychology*,[1] p. 223

TOPICAL OUTLINE

General Nature of Attitudes
- *A*. Partly innate and partly acquired (permanent neural patterns that shape and direct concrete mental experience)
- *B*. "Attitude" a generic term including
  - I. Apperception
  - II. Interest
  - III. Desire
  - IV. Attention
- *C*. Relation
  - I. To habits
  - II. To disposition
  - III. To thought
  - IV. To prejudices, etc.

Attention an Attitude of the Motor Type
- *A*. Origin
  - I. Through transmuting one of several simultaneous sense perceptions into specific motor responses

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II. Through coördinating and adjusting sense impressions and ideas to specific reactions where innate and habitual mechanisms fail or are lacking

B. Nature

I. Conscious aspect (degrees of vividness occurring in the focal and marginal fields)

II. Motor aspects (sensory and ideational processes changing to explicit and implicit motor responses)

C. Conditions which steer the neural and mental reactions of attention

I. Objective, or external

1. Intensity and duration of the stimulus
2. Shape, size, motion, and novelty of the stimulus
3. Extent of the receptor affected

II. Subjective, or internal

1. Idea of the moment
2. Purpose
3. Education, training, etc.
4. Duty, obligation, social pressure

D. Kinds of attention according to

I. Origin

1. Innate or native
2. Acquired

II. Stimuli

1. Sensorial, objective, explicit
2. Intellectual, subjective, implicit

III. Development

1. Involuntary or passive
2. Voluntary
3. Spontaneous or nonvoluntary

E. Motor adjustment

I. Kind

1. Adjustment of sense organ (adaptive movements)
2. Adjustment of vital organs (organic movements)
3. Adjustment of muscles (useless movements, correlated movements)

II. Purpose

1. To expose the receptors favorably to stimulus
2. To inhibit disturbances of vital processes
3. To inhibit and to facilitate the attentive response by excess motor reaction

F. Mobility

I. Shifting of attention

1. Characteristics
2. Probable causes

II. Fluctuation

1. Rhythmic changes
2. Rivalry (characteristics)

III. Fundamental laws of reaction of attention
 1. Law of selection
 2. Law of advantage
 3. Law of shifting
 4. Law of degrees of consciousness

G. Duration
 I. Sustained attention (factors involved)
 II. Distraction
  1. Effect on effort
  2. Methods of overcoming
 III. Divided attention and effect on amount of work done
  Meaning of the term and relation to habits
 IV. Span of attention

H. Attention and suggestion
 I. Problems of inhibition arising from opposite motor systems involved in both
 II. Attention a response to sense perception, to imagery, and to action; suggestion a response either to an action or to a belief
 III. Therapeutic value of both

INTRODUCTION

Attitudes: attention. It is probable that a sheaf of fodder or a mouse would make about the same optical impression as such on the respective visual centers of a deer and of a cat. But all observation is to the effect that the subsequent courses of the sensory impression in the two animals are so divergent in behavior and so different in results in respect to each object that the mouse seems practically nonexistent for the deer and the fodder for the cat, or that the deer's consciousness is all fodder and that the cat's is all mouse for the time being. The object mouse or fodder excites similar receptors in the two animals and produces a characteristic response in one and perhaps nothing observable in the other. The elaboration and transmutation of the sense impression of the mouse in the cat's consciousness can only be inferred from the cat's responses, and the fate of the fodder impression in the deer's consciousness must be likewise interpreted (**10**: 218). Such considerations lead to the notion that the motor effects of sensory impressions depend in every instance upon the manner of organization of the neural tissues between sensory and motor centers of the brain or upon the

nature of the change that a mental operation undergoes in passing from the sensory to the motor phase (**9**: 134). The service performed by transfer lines between railway terminals and wharves of a city furnishes a simple analogy. Two travelers, A and B, reach a terminal station of railway X; A will continue his journey over road Y that starts from its own station in another part of the city, and B will continue his journey on steamship line Z that sails from docks in still another part of the city. To make the right changes the travelers use vehicles of a city transfer company. As long as the two travelers were on road X they formed a part of the same passenger list, but on leaving station X they separate, go in different directions, and become members each of a different passenger list, one continuing to be an overland passenger and one becoming a steamship passenger — all the result of the city transfer lines.

This analogy serves to emphasize the following points: (1) the guiding, coördinating, and shunting function of the sensorimotor transfer centers; (2) the possibility of infinite variations in animal behavior as conditioned thereon; (3) why the same situation so often produces such diverse responses, especially in human behavior. The arrangement and function of these transfer centers are known and described as integration and coördination, and their conscious correlates are here termed attitudes. This latter term, when so used, evidently refers to fundamental and permanent factors which underlie and determine myriads of secondary operations (**10**: 220–221).

Since "attitude" may designate any of the conditions and processes common to the transfer of mental elements and their compounds to specific forms of behavior, it must necessarily be a generic term, comprehending many types. The history of psychology shows that such is the case: apperception, interest, desire, feeling, meaning, attention, and other types were studied and described long before attitude was used in the technical sense given it here.

This chapter is devoted to the study of attention, one of the most striking classes of motor attitudes. Only a brief account can be given here of its conditions, nature, and activities; the

more important laws and their practical applications should be derived from the experiments which follow.

Conditions. The necessity for responses of attention depends primarily upon the fact that the individual is confronted with several sense perceptions, or ideas, or things to do, at one and the same moment. Thus, of many voices at a social gathering one attends and responds to only one at a time; in seeking for the right word one finally holds to the one that seems most apt; in administering to the wounded the physician attends to each in the order of greatest need (**1**: 67).

Again, the necessity for attending may depend upon the complexity and the difficulty involved in changing a sense impression to a motor response. Some of our responses occur independently of conscious attention or control; for example, the dilation of the pupil of the eye, the responses of respiration, swallowing, coughing, shivering, dodging, etc. True, consciousness may accompany, or bear witness to, some of these actions, but the transfer mechanism appears to be such as not to require attention. The manifold adjustments involved in threading a needle, steering a ship, writing a deed, dictating a brief, require constant attention owing to the complex character of the conditions.

Nature. The essential nature of the attentive consciousness is that of clearness or vividness; "attention is identical with sensory clearness" (**20**: 267). It increases the clearness of the sensations and images attended to and obscures those attended from; in this sense attention is the relation between the focal and marginal fields of consciousness as to clearness and distinctness (**15**: 266–268). Another constant feature sustaining a conditional relation to clearness is the principle of *motor opposition.* Observations show that certain systems of movements are made in opposition to and preclude the making of others; thus, I cannot sit down and stand up, or open and close my hand, or eat and sing at the same time. Two opposing attitudes cannot produce full, free, simultaneous motor discharges. I cannot attend to writing this paragraph and enjoy the music in the park close by. The motor adjustments necessary for enjoying the music block the thought-writing paths. Motor discharges for

sensations and ideas, or for a harmoniously related system of ideas, if sufficiently clear, block the motor discharges of sensations and ideas that lead to opposite action. All the more important problems of attention, with the exception, perhaps, of fatigue, develop from these two principles: clearness and motor opposition. Fluctuation, duration, and range of attentive states center about clearness, whereas reënforcement, inhibition, concentration, and diffusion of the attentive field, as well as the specific forms of attention (involuntary, voluntary, and spontaneous), are bound up with the principle of motor opposition (**13**: 95–106).

Functions. In naming the conditions that make attention necessary in consciously controlled reactions, its functions were suggested especially where sense impressions follow upon critical observation or responses upon deliberate selection. When an individual is confronted with a complex problem, whether purely physical or intellectual, he proceeds to examine, to separate, to compare, to reject, and to select. If the problem is physical, he explores, searches, and compares, and then responds in the light of the information thus gained; if intellectual, he concentrates, studies, and reflects, and then acts in the light of his conclusions. If the cook is to sample the broth, tasting movements are made to the end that proper amounts of condiments may be added; if a brief is to be written, the facts and the laws are duly examined in order that they may be recited in proper sequence, etc. "Attention is really an activity of the relating, adjusting kind, its work is done when the relation between the mind and the thing attended to is once established" (**1**: 79).

Experiment 43 A. To observe the Effect of Attention upon Clearness or Distinctness of Pressure Sensation (One Student)

Material. No material required.

Procedure. S sits comfortably in his chair and with closed eyes attends to the sensations arising from the pressure of his shoe.

Results. *Subject's report.* Note respiration, attitude of body, other sensations besides pressure, affective processes. What was the effect of attention on clearness? From your experience what effect has clearness on attention? Give examples.

EXPERIMENT 43 B. To observe the Effect of Attention upon Clearness of Sound Sensation (One Student)

Material. Metronome.

Procedure. S, first with eyes closed, determines which of the two beats of a metronome beating seconds is the weaker. If the beats seem equal, he gives attention first to five beats to the right, and then, after an interval of one minute, to five beats to the left. But if the beats seem of unequal intensities, S gives attention first to five of the weaker and then, after a minute, to five of the stronger.

Results. Subject's report. What effect, if any, had your attention on the clearness? What effect has the intensity of a stimulus on attention? Illustrate from experience. Determine whether the beats attended to seemed more intense or more distinct. Give reasons why they may be more distinct. If you think they are made more intense, give reason why. To answer this question consider what causes intensity of sound vibration.

Inference. State the first law of attention.

READINGS. **2**: 80–81; **14**: 2–3; **19**: 110–111; **20**: 279–280.

EXPERIMENT 44. To observe the Effect of Intensity of Stimulus on Attention (Class Experiment)

Material. Three lists of fourteen words each, the words being of uniform length.

Procedure. The instructor reads the first list in a clear, even tone at the rate of one word per second. This list is reproduced at once by the class in writing. The second list is now read, the instructor reading at the same rate, but emphasizing three words by pronouncing them in a loud tone. This list is reproduced in the same way. In the third list the instructor emphasizes three words by pronouncing them in a distinct whisper. This list is reproduced in like manner. The instructor now reads the three lists in order and each student notes in each of his lists the number of words remembered.

Results. Subject's report. Give an account of the effect of intensity on reproduction.

Arrange a table showing the number of students correctly reproducing each word (represented by numbers from 1 to 14) in each of the three lists. Place a small cross in the square under the number of the word emphasized by loudness and a star to show the number of the word emphasized by whispering. From the table make three graphs on the same base for purposes of comparison.

Discussion of results. What can you tell from the table as to the effect of intensity on attention? State all the principles you can derive from a study of the graphs. Are there any words remembered better because of position? any remembered less well because of position?

Inference. State the second law of attention.

READINGS. 7: 39–44; 14: 5–7; 17: 167–168; 18: 246; 20: 276–281.

EXPERIMENT 45. To observe Effects of Changes in Meaning on Changes in Attitude (Two Students)

Material. Two sets of words misspelled by disarranging the letters:

SET I	SET II
1. enrsi	1. hgnti
2. tsora	2. tignesa
3. edlare	3. tmhosre
4. ahepc	4. ostat
5. namro	5. dysut

The letters of each word can be arranged so as to form two different words. Both sets should be typewritten on small cards, and the cards of each set should be numbered consecutively.

A prepared form, as shown in Table XVII, in which S writes his responses should also be provided.

Procedure. For each misspelled word there are two suggestions, (*a*) and (*b*). The number of the suggestion corresponds to the number of the word in the set and on the card.

Allow, if necessary, two minutes in which to form a word. If a word is not made in two minutes, pass to the next word, and so on until the list is finished; then return in order to the unfinished words. Giving a sample word, as "mlpa" ("palm" and "lamp"), and requiring S to form the words according to the conditions to be observed insures an understanding of the experiment.

S makes the following entries in the prepared blank form: (1) the correct word for card 1 after *a* in column headed "Reaction"; (2) two words after *a* in column headed "Post-Reaction." Such words are any suggested by the correct word after the manner of free association (see Experiment 7 A). Having entered the associated words, S now writes in the left-hand column, "Pre-Reaction," pertinent experiences that occurred before the recognition of the correct word. The brief notes in this column should contribute to the subject's report.

A key to the words is given in Appendix, p. 325. To keep the conditions fairly constant, E should use the words of the text in giving the meaning of the prospective word. It is not desirable to puzzle S, but E should give no hints other than those contained in the text.

After completing Set I, E and S exchange places and use Set II.

Directions for Set I

Card 1. At signal "Ready" E shows S card 1, Set I, and says: (*a*) "Mentally arrange the letters on this card so as to spell the name of a product of the pine tree." As soon as S speaks the word, E then says: (*b*) "This time mentally arrange the letters so as to spell a word relating to an instrument used for sound signals."

Card 2. (*a*) "Mentally arrange the letters on this card so as to spell the name of an early financier of New York City." (*b*) "This time mentally arrange the letters so as to spell the name of a method for cooking meats."

Card 3. (*a*) "Mentally arrange the letters on this card so as to spell a name given to a person engaged in merchandising." (*b*) "This time mentally arrange the letters so as to spell the name given one who directs the activities of an organization."

Card 4. (*a*) "Mentally arrange the letters on this card so as to spell the name of a fruit." (*b*) "This time mentally arrange the letters so as to spell an adjective describing a low-priced article."

Card 5. (*a*) "Arrange the letters of this card so as to spell the word describing our alphabet." (*b*) "This time mentally arrange the letters so as to spell the name of a nobleman's landed estate."

Directions for Set II

Card 1. (*a*) "Mentally arrange the letters of the card so as to spell the name of a species of hawk." (*b*) "This time mentally arrange the letters so as to spell a synonym for object."

Card 2. (*a*) "Mentally arrange the letters of the card so as to spell a term used in describing the work of an usher in an audience." (*b*) "This time mentally arrange the letters so as to spell the name of a type of behavior that may annoy and vex one."

Card 3. (*a*) "Mentally arrange the letters of the card so as to spell the effect of insufficient air." (*b*) "This time mentally arrange the letters so as to spell the name of a bottle."

Card 4. (*a*) "Mentally arrange the letters of the card so as to spell the name of a weasel." (*b*) "This time mentally arrange

the letters so as to spell the name of a custom used to honor a person at a banquet."

Card 5. (*a*) "Mentally arrange the letters of the card so as to spell an adjective describing objects in a neglected room." (*b*) "This time mentally arrange the letters of the card so as to spell the name of a student's chief work."

Results. *Subject's report.* Describe the effect of the cues in directing attention, in changing the prominence of certain letters, in arousing and inhibiting trains of associative responses; alternation of bodily tension and relaxation; anticipatory effects, that is, a consciousness of the word about to appear.

Experimenter's report. Show the number of trials per word per meaning and the results arranged in a form as given in Table XVII.

TABLE XVII. FORM FOR RECORDING RESULTS SHOWING CHANGE IN ATTITUDE TOWARD WORDS WITH CHANGE OF MEANING

CARD	PRE-REACTION PERIOD	REACTION PERIOD	POST-REACTION PERIOD
1	*a* *b*	*a* *b*	*a* *b*
2	*a* *b*	*a* *b*	*a* *b*
3	*a* *b*	*a* *b*	*a* *b*
4	*a* *b*	*a* *b*	*a* *b*
5	*a* *b*	*a* *b*	*a* *b*

Discussion of results. Did any of the suggestions act as a hindrance? Did you form any of the words wholly from the cue, ignoring the letters? If so, specify. Did any of the cues fall on associative "blind spots," as it were? Do you discover a connection between richness of associations aroused by the cue and familiarity with the word? Give cases. What two sets of facts entered in the blank form show that a change in meaning of a word causes a change of attitude?

Inference. State the effect of change of meaning on attitude.

READINGS. **22**: 332–334; **23**: 248.

EXPERIMENT 46. **To study Sustained Attention (Two Students)**

Material. Stop watch or clock with second-hand; nine problems similar to those here given, based upon familiar material but of such complexity as to require continuous attention for quick solution (for group experiment provide each subject with a separate page containing these or similar problems).

1. Three different letters occur only once in this proverb; write the second one to occur: "Time and tide wait for no man."
2. Two different letters occur only once in this proverb; write the first to occur: "Those in disgrace always want to disgrace others."
3. Find the letter in "Constantinople" that occurs just as far to the right of *C* as it does to the right of *a* in the alphabet.
4. Three different letters occur only once in the following proverb; write the last to occur: "The doorstep to the temple of wisdom is a knowledge of our ignorance."
5. Write the letter that occurs only once in this proverb: "A friend in need is a friend indeed."
6. Three different letters occur only once in this proverb; write the first one to occur: "It is an ill wind that blows nobody good."
7. Find the letter that occurs oftenest in the following proverb: "A good name is rather to be chosen than great riches."
8. Suppose that the first and third letters of the alphabet were interchanged, also the fourth and sixth, the seventh and ninth, etc., and write the letter which would then be the fifteenth in the alphabet.
9. Find the seven different letters that occur only once in this proverb: "Pride goeth before a fall."

Procedure. Members of class work in pairs, one as S and the other as E. Papers are distributed blank side up. At signal "Go" S turns over paper and begins with the first problem and solves each in turn, skipping none. E observes from clock the time required for solving the nine problems.

Results. Subject's report. Report, on basis of interest, ways for holding conditions in mind, suppressing disturbances, etc.

Experimenter's report. Give (1) total time in seconds for solving the nine problems; (2) corrected time. To find the value of the corrected time, use the following formula, where C. T. is corrected time, T. is total time, and E. is number of errors.

$$\text{C. T.} = \text{T.} + \frac{\text{T.}}{9} \times \text{E.}$$

Key to problems is written on blackboard.

Summary of corrected results of class may be placed on board for comparison and discussion and from which an inference should be drawn.

READINGS. **1**: 76–77; **15**: 274–276; **20**: 291–293; **23**: 257–259.

EXPERIMENT 47. **To demonstrate the Laws of Mobility of Attention (Two Students)**

A. Law of Rivalry

Material. Metronome; stereoscope; three cards; (1) card to fit stereoscope, about $2\frac{1}{2}$ in. wide, containing a red and a green square $1\frac{1}{2}$ in. on side, each about $\frac{3}{4}$ in. distant from the middle of the card; (2) blue-yellow card; (3) card containing two white squares of the same size and arrangement as card 1, having parallel lines at equal distances extending obliquely upward from left to right in one square, and from right to left in the other; a series of numbers from 1 to 120 inclusive on sheet of paper.

Procedure. S fits card 1 in the stereoscope, adjusts it, and at once calls out "Red" (if that color is visible first). E begins to count metronome beats silently, writing "r" (if color is red) over figure 1 in the prepared series. S calls out when the field changes to green and E checks "g" above the number of the beat he is counting, continuing this until the two minutes are up. The same is tried with a similar card of blue-yellow squares and with the squares of card 3. S reports "b" or "y" according as the field is blue or yellow, and E writes the letter over the digit as with card 1. With card 3 "r" or "l" is reported. S makes ten observations of the field, looking away or closing his eyes for a few moments after each observation to find if one color or figure appears first uniformly or if there is variation in the first appearance of the field. This is done for all three cards.

Results. *Subject's report.* Describe field changes and order of appearance.

Experimenter's report. From your records make tables showing the number of seconds in each period of attention: card 1, for red and green; card 2, for blue and yellow; card 3, for the dissimilar figures. The average length of a period for each color and for each figure is found by dividing 120 by the number of periods that occurred in two minutes. From these tables make three diagrams (see Fig. 13), taking a center line for each, with as many equal divisions as there were periods in the two minutes of observation and representing the relative duration of each period by rectangles plotted above and below the base line according to a convenient unit of length.

B. Law of Shifting.

Material. Metronome; book figure and cube figure (see Fig. 12) (use both if possible, since they do not evoke the same responses); series of numbers from 1 to 120.

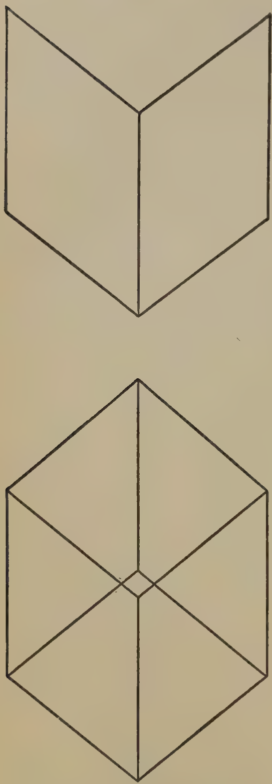

FIG. 12. Reversible figures

Procedure. Begin with the upper figure. S fixates it for two minutes at its central point—after a preliminary period in which he notes several shifts of the book, "out" to make the book stand with its back to him, "in" as the book appears to him open. S in a low tone calls "Out" or "In" as the book shifts. E has prepared on paper a series of numbers from 1 to 120. He counts the metronome beats for himself and records over the proper number a "+" when S says "Out," and a "–" when S says "In."

Results. *Experimenter's report.* From the results calculate length of a period of attention as recorded by plus and minus signs. Also make a diagram of the attention wave to the same scale as in part *A*.

Discussion of results. According to standard texts, how long can one attend to the same thing? How long was the period for S in part *A* in each case and in part *B*? Describe the situation in both experiments. What two inconsistent responses are possible in part *A* in each case? What in part *B*? How are the two different responses explained? How many responses were made at once?

Inference. What, then, is the law of shifting?

C. Law of Advantage.

Material. (1) Blue-yellow card as in part *A*, except that in the center of the yellow square a small dot has been made with india ink; (2) blue-yellow card with ink dot in the blue square.

Procedure. The same as in part *A*.

Results. *Subject's report.* Describe the rôle played by the ink dot in the blue and yellow squares respectively.

Experimenter's report. From the results calculate duration of a period of attention as indicated in part *A*.

Discussion of results. Which appeared first in card 1, blue or yellow? in card 2? Why? What were the periods in seconds for blue and yellow respectively in each card? What is the law of advantage? What

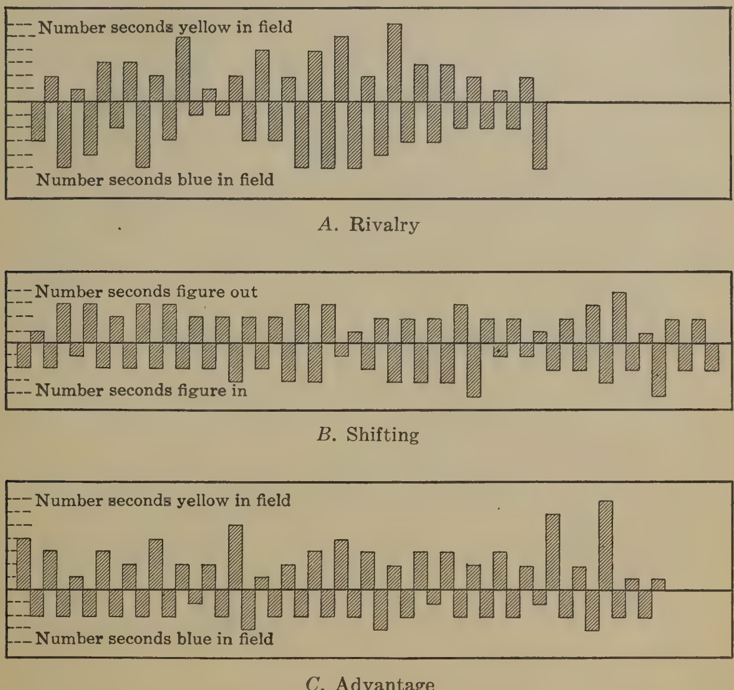

FIG. 13. Number of periods occurring in two minutes and duration of each in seconds for conditions of rivalry, of shifting, and of advantage

can you conclude as the law of shifting? Will a person who has a love for music be more likely to attend a prize fight or a symphony played by a fine orchestra? Give illustrations from everyday life showing how a tendency may facilitate response. Give practical examples of reactions in which appear the law of advantage; the law of shifting.

Inference. State these three laws.

READINGS. **12**: 267; **23**: 251–256, 263.

EXPERIMENT 48 A. To study Fluctuation of Attention in Vision

NOTE. It is possible for six subjects to perform this experiment at once, each with an experimenter to make records.

Material. The Masson disk, a white disk containing along an imaginary radius a series of small black squares at equal distances apart; color wheel; headrest.

Procedure. The Masson disk is rotated on a color wheel. S, with head supported, observes for two minutes the faintest of the gray

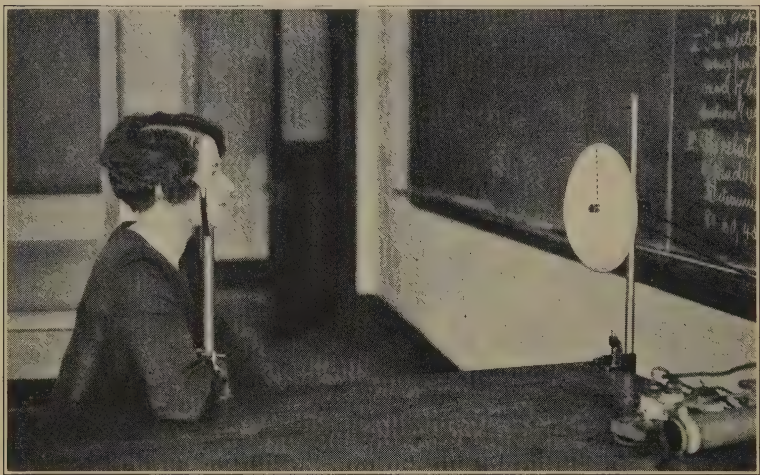

FIG. 14. Masson disk ready for rotating

rings, and as it appears and disappears calls softly, "In," "Out," E keeping a record, as in preceding experiments, with the seconds metronome and a prepared series of numbers.

Results. Subject's report. Verbal reports of "out" and of "in" periods.

Experimenter's report. Calculate duration of "out" and "in" periods, respectively. Compare the length of an average "out" and an average "in" period.

Discussion of results. What is the duration of a complete attention wave including an "out" and an "in" period? What is its mean variation? What is the range? Give everyday illustrations of fluctuations in vision.

EXPERIMENT 48 B. To study Fluctuation of Attention in Hearing

NOTE. There should be two experimenters, and observations should be made in a quiet room.

Material. Watch.

Procedure. E holds a watch on a level with S's ear and withdraws it slowly, stopping at a point where the ticking is just audible to S. A second E measures the distance and keeps the record. S attends to the ticking; when it is not audible he says "no"; when the sound is heard again he calls "yes." The second E keeps the record of the number of fluctuations in two minutes, using a watch with second-hand rather than the metronome, and hence arriving at only the number of changes in two minutes and the average length of an attention wave.

Results. Compare results in this case with those in Experiment 48 A.

Discussion of results. Discuss the cause of fluctuation waves and the various theories that have been suggested. In the whole matter of mobility of attention to sense stimuli make a general statement from your results, especially as to time order.

READINGS. **12**:318–320; **14**:69–82; **17**:158–165; **19**:111–113; **23**:254–255.

EXPERIMENT 49. To demonstrate Laws of Combination in Attention

A. When the Objects are Similar (One Student).

Material. Stereoscope; several cards showing two similar figures about 1½ in. apart.

Procedure. The cards are viewed through the stereoscope.

Results. Subject's report. State what is observed.

B. When the Objects are Unlike and with or without Meaning (Class Experiment).

Material. A large tachistoscope, as shown in Fig. 15; a series of cards, three with long words and three with the letters contained in these words at the same distances apart but entirely transposed. The transposed letters are shown first. The cards used should be arranged by the instructor for the experiment. The following shows sample material for a set of cards:

1. Twelve letters arranged thus: ntcrntsucoio.
2. Twelve letters: rnlispaiedte.
3. Ten letters: naitgnroee.
4. The word "construction."
5. The word "presidential."
6. The word "generation."

This tachistoscope is made from 1-inch by $\frac{5}{8}$-inch lumber; the foot pieces from 2-inch by 4-inch lumber. The upright is mortised in the foot pieces and reënforced by heavy T irons; foot pieces are 75 cm. long. Height and width over all is 2 m. by 55 cm. The lower edge of the lower rectangular exposure is 1 m. from the bottom, the opening is 40 cm. by 15 cm.; the upper exposure for serial stimuli is 50 cm. from top and is 20 cm. by 8 cm.; it is made by two slits 1 cm. wide, the upper one at an angle of 45 degrees up and the lower one at the same angle down. Exposure at the lower opening is made by a screen, 112 cm. by 50 cm., sliding in two lateral grooves. The screen hangs at the top by a catch; the rate of fall is controlled by counterweights on a cord running over three pulleys. The opening in the sliding screen is 40 cm. by 15 cm. A card-holder screen 46 cm. long with lateral grooves 10 cm. deep is placed behind the screen and coincides with the lower exposure.

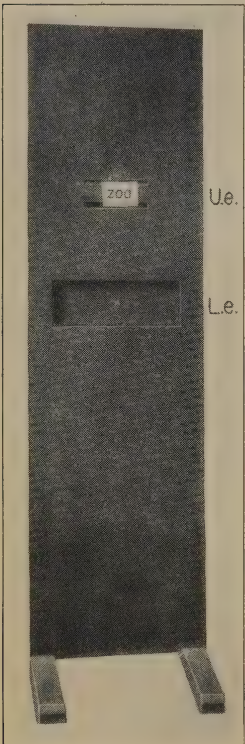

FIG. 15. Tachistoscope (Wundt pattern)

U.e., upper exposure; *L.e.*, lower exposure

Procedure. With the class arranged in pyramid fashion, the instructor exposes the cards bearing words with disarranged letters in the order as listed above (1, 2, 3) in the large tachistoscope, the large shutter, regulated by a counterweight, dropping at intervals of from one half to one fourth of a second of exposure. Students record what is observed as each card is exposed. After the cards have been shown in this manner, the instructor shows cards 4, 5, 6, and S writes down beside his first results, from cards 1, 2, 3, what is printed on each card.

Results. Subject's report. Make two records for each card.

Discussion of results. Compare the records of cards 1, 2, and 3 with those of cards 4, 5, and 6 for correctness of results. Considering one letter as a unit of attention, compare units of cards 1 and 4, 2 and 5, 3 and 6. What made the difference in results?

Inference. State a law of combination in responses of attention.

READINGS. 23: 263–264; 24: 235–251.

EXPERIMENT 50. To study the Concentration of Attention (Two Students)

Material. A suspended red-paper star; clock with second hand.

Procedure. 1. The instructor tells the students to hold the star in mind for two minutes, gazing at it fixedly, but not to think things about it, keeping a passive attitude. At a given signal all subjects concentrate on the star, as directed, until the instructor calls "Time." Should attention wander, S indicates it to E by raising a pencil, with an unobtrusive movement of the hand from the wrist, immediately lowering, and raising again at another change. E keeps the record of these changes.

2. S looks at the star again for two minutes. This time he asks himself questions about it: the color, exact size, distance, material, etc. The changes are indicated to E as before. E and S now exchange places and the experiment is repeated.

Results. Subject's report. S writes an account of difficulties in both cases.

Experimenter's report. E calculates and S records the number of shifts of attention for one minute in parts 1 and 2.

A table is written on the board containing the number of changes for each member of the class, recorded in two columns, for parts 1 and 2 respectively, with average and mean variation for each column.

Discussion of results. Compare this shifting with that in the experiments on the mobility of attention in both cases. Compare it with standard results. What difference is noted in part 2? What causes this difference? Give practical examples of the change of attention; of the methods of concentration used. Apply this to teaching.

Inference. Give a brief statement of your general conclusion.

READINGS. **1**: 77–79, 345–346; **21**: 13, 100; **22**: 128.

EXPERIMENT 51. To study the Control of Attention (to keep an Object of Thought out of the Mind) (Two Students)

Material. The last book that has interested S as an object of thought.

Procedure. 1. The instructor announces that he is to give a subject about which S is not to think for two minutes, but that he is not to think on any other definite subject, letting his mind wander freely. The instructor gives the signals to begin and to stop, and whenever the forbidden subject returns S gives the same signal as was made in Experiment 50 to E, who records results in the same manner.

2. The procedure is the same as in part 1, except that now the instructor gives another subject of about the same interest as the first, about which S is to think and upon which he is to concentrate to the exclusion of the first. This may be any book or current event which the instructor knows will prove of interest to the class as a whole. S signals to E when the forbidden subject comes back to mind. E and S now interchange places and different subjects are given.

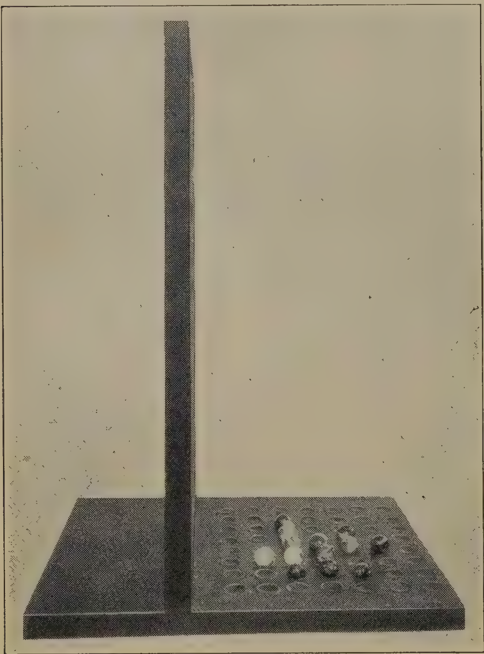

FIG. 16. Exposure board

Subject sits at left of vertical partition; experimenter at right

Results. Subject's report. Give an account of the two procedures as to difficulty, etc.

Experimenter's report. In which part of the experiment did the forbidden subject return oftener?

On the board make a table of the changes for each member of the class, recorded in two columns, for parts 1 and 2 respectively, with the average and the mean variation for each column.

Discussion of results. Discuss the variation in the results reported by different members of the class. Contrast with shifting in Experiment 47, *B*. Explain. Give three practical examples of this method as a control of attention.

Inference.[1] State how attention may be controlled.

READINGS. **21**: 14, 101; **23**: 259.

[1] Experiments 51 and 53 are modified forms of Experiments VI and VII in *An Introduction to Experimental Psychology in Relation to Education*, by C. W. Valentine, and are used by permission of University Tutorial Press, Ltd.

EXPERIMENT 52. To determine the Span of Attention for Touch (Two Students)

Material. About one dozen marbles of the same diameter; a rectangular board, 11 in. by 14 in., having a vertical partition at one end 18 in. high, the baseboard containing fifty-six saucerlike cavities arranged in seven rows, eight in a row (Fig. 16); a ruled blank table for results.

Procedure. Place the board so that the upright is between E and S, E being in front of the receptacle and S on the other side, so that the upright piece hides the marbles from his vision. S closes his eyes and E places a large number of marbles, ten or twelve, in the cavities of the board, in no regular order, but so that the board will cover them. E now takes S's right hand, which must be slightly spread open, and places it down firmly on the marbles for one second, lifting it squarely up and not permitting it to feel about. S states the number of marbles felt, if he is fairly sure; if not, he simply says "Many." Random guesses are not permitted. E fills out the table which he has before him as S gives results. Thirty trials are made with the descending series; that is, with the number of marbles decreased, but not with perfect uniformity, until a number is reached which is correctly perceived several times in succession. Starting with a number less than this, a similar ascending series is now made. In both series the number should remain constant at times during several successive trials. E should be very careful, in the preparation of tables for S, to see that all numbers are used and no one too many times.

Results. Table XVIII gives S's individual results as recorded by E. Table XIX, on page 120, is a frequency distribution arranged from Table XVIII. In this table the span will appear, which is the number correctly perceived 75 per cent, or nearly that, of

TABLE XVIII. INDIVIDUAL JUDGMENTS

TRIAL	ASCENDING SERIES		DESCENDING SERIES	
	Placed	Perceived	Placed	Perceived
1				
2				
3				
.				
.				
.				
20				

TABLE XIX. FREQUENCY DISTRIBUTION FROM TABLE XVIII

Number Presented	Times Presented	Number of Correct Judgments	Percentage of Correct Judgments
3			
4			
5			
6			
7			
8			
9			
10			
11			

TABLE XX. CLASS RESULTS SHOWING SPANS AND FREQUENCIES FOR TWENTY-FOUR STUDENTS

Number of Students (Frequency)	Span	Percentage of Correct Judgments
5	3	75
8	4	75
5	5	75
2	6	75
1	7	75
3	8	75
	Mean, 4.8 Mode, 4.0 Median, 4.0	

the times presented. Table XX is a class table and is compiled from individual results, a sample from actual class work being given in full.

Discussion of results. Do your results show evidence of fatigue? Is there any evidence that the perception toward the end of the respective series was influenced by earlier perceptions in the series? Why did you take as your span the number perceived correctly 75 per cent of the times? Point out the errors which may have occurred in this problem. How does the average class span as found here compare with that given in standard texts?

Inference. Define the span of attention and give result of experiment.

READINGS. **1**: 80–81; **11**: 123–144; **12**: 321–322; **14**: 64–68; **22**: 163–164; **23**: 261–262.

EXPERIMENT 53. To study Divided Attention (Two Students)

Material. Pen and paper; stop watch.

Procedure. 1. The instructor gives the signal to begin, and S counts softly backward from 150 for one minute by the stop watch. When time is called, E writes down the last number.

2. The entire class now writes in order the letters forming the words, "George Washington, First President," as rapidly as possible, writing each letter separately and beginning at "G" again immediately on finishing "t," writing the letters as many times as possible during one minute. The entire class writes the letters, and the instructor keeps time.

3. S now performs, as well as he can, both operations at once, counting backward aloud, and at the same time writing the letters, as in the first instance, continuing the two operations for one minute. When "Time" is called E records the last number counted by S.

Results. Subject's report. Were you conscious of performing two operations at once? If there was a plan in the third series, describe it. The number of numbers counted by S is found by subtracting from 150 the last number written down by E. Count and record the number of letters written. Record the results in a table. Table XXI gives results of one individual.

TABLE XXI. RESULTS IN DIVIDED ATTENTION

	NUMBER OF NUMBERS	NUMBER OF LETTERS
Undivided attention (1 and 2)	74	112
Divided attention (3)	33 (44.5%)	30 (26.8%)

Discussion of results. If both operations had been performed at once, that is, if each operation had taken its own time as in the first series, independently of the other, how many numbers would have been recorded in the third series? (Evidently 74, or 100 per cent.) How many letters would have been recorded in the third series? (112, or 100 per cent.) In this case what would have been the total per cent of efficiency gain? If the two operations had interfered with each other and the attention had been proportionately divided so that no two operations were performed simultaneously, how many numbers would there have been in the third series, and what per cent of the first series would this be? (37, or 50 per cent.) How many letters would have been recorded in the third series, and what per

cent of the second series would this be? (56 letters, or 50 per cent, thus giving results of one half for each in their half-minute proportion of time — time neither lost nor gained.)

In the table 44.5 per cent of numbers was obtained in the third series, giving a loss of 5.5 per cent. Of the letters, 26.8 per cent was obtained, giving a loss of 23.2 per cent. It can be seen that any per cent over 50 per cent is a gain in efficiency, and any per cent under 50 per cent is a loss.

From the results obtained from your own work, what conclusions can you give? If you found a gain in both operations, would that prove that you had performed two operations at once? What other explanation could be given? What individual characteristics favor the performance of two tasks simultaneously? (Note individual differences in the class.) How may the apparent divided attention of musicians and jugglers be accounted for? Give examples of other tasks which apparently indicate that attention is paid to more than one operation at the same time.

Inference. Draw a general conclusion.

READINGS. **8**: 405–415; **14**: 69; **21**: 15, 102; **23**: 260–261.

EXERCISES

1. Why does a mother hear the cry of her child when no one else in the room is aware of it? Give example of another attitude of the mother.

2. A telegram comes to Mr. A. It reads: "My son John was drowned at noon today." Point out the difference in the attitude of Mr. A if the pronoun "my" had been "your."

3. Why, when studying or reading, does one sometimes become suddenly aware of the ticking of a clock close by?

4. One can knit and converse, or even read, at the same time. Explain attention reactions in such a situation.

5. When a trained pianist can play and converse at the same time, does he attend to each individual key? Explain.

6. In hitting a ball in tennis, to what does the skilled tennis player pay attention? Formulate a general rule which this example illustrates.

7. Why do skilled workers in a factory often sing at their work and often do better work when singing?

8. An experienced driver can tell from the sound of his engine whether or not it is working as it should, whereas one who does not drive a car would notice no difference in the sound. Why is this?

9. Our attitudes are formed by our reactions, accompanied with moderate feeling-tone. Give suggestions as to ways of forming the following attitudes: an optimistic attitude; a conscientious attitude toward one's work; an interested attitude in regard to study or in connection with one's associates; a critical attitude.

10. What are some of the attitudes you have acquired at college? Distinguish these from habits.

11. Why must one fail to succeed if one has an attitude of indifference toward one's work? How can this attitude be remedied?

12. Do moving pictures cultivate voluntary (active) or spontaneous (passive) attention? Support your answer by concrete evidence from your own observation.

13. Give an argument to show that voluntary attention marks the peak of mind development.

14. Integration of the personality is the essential characteristic of the normal mind; that is, the normal mind is one capable of bringing its powers to a focus on a given subject. How does this principle show the importance of attention and its laws?

15. Why are the eyes and the ears of the savage far more keen in finding game than those of civilized man?

16. Why can the trained musician detect discords and faint changes of pitch where the untrained man would hear only harmony and the same tone?

17. A tailor and a bishop visited Niagara Falls. The tailor's reaction was expressed thus: "What a fine place to sponge a piece of cloth!" The bishop exclaimed reverently, "God of grandeur, what a scene!" Explain the cause of the difference in these comments.

18. Why does a horse shy when a newspaper blows across the road but not at a paper lying in his path? Give other examples of the same cause and effect.

19. A young girl was not paying attention in class. The instructor at the close of a sentence called upon her to repeat what he had just said. This she did immediately in the exact tones and words of the instructor. She said afterwards that she was not paying attention and could not have recollected the sentence; in fact it seemed to come automatically. Explain this on the principle of focal and marginal attention.

20. What movements are characteristic of attention? Watch an audience and list the movements (1) in attention, (2) in inattention, preparing to report to the class at a designated period. Why is one list so much longer?

21. Is attention held by the commonplace of daily life or by the novel? Give an example justifying your answer.

22. Take six well-known advertisements and select the elements which attract attention in each. (Or the instructor may select the advertisements and present them to the class.)

23. What is the object of the chorus in a song?

24. Why does the repetition of a line or a word at regular intervals, as in the Psalms or in certain poems and stories, add effectiveness? Give examples.

25. How does the mind-reader make use of the phenomena of attention?

26. Give a reason from your study of attitudes why it is best never to repeat gossip which may reflect on a person's character. Show how the same principle may hold good in many situations in life. For example, give a concrete illustration from politics and one from religion of attitudes formed in this manner. Show how this principle has a bearing on loyalty.

27. From the first law of attention you learned that attention increases clearness. What would be the application of this law to pains, especially those of nervous origin? Give a reason for your answer and an example from your own experience. Could diseases be cured on this principle?

28. A peach-grower in Georgia hired a band to play while his laborers were sorting peaches. He found that this was good business. What laws of psychology were applied?

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CHAPTER VI

RETENTION AND ASSOCIATION

1. Retentiveness has two aspects or degrees: First, the persistence or continuance of mental impressions after the withdrawal of the external agent. . . . We have, secondly, the power of recovering, or reviving, under the form of ideas, past or extinct sensations and feeling of all kinds, without the originals and by mental agencies alone. — ALEXANDER BAIN, *The Senses and the Intellect*, p. 323

2. Before asking how memories are retained we must inquire where they are retained. Two possibilities have been suggested in the history of the science: one that they are retained in mind or as mental states, the other that they are held in the nervous system. The latter view is at present generally accepted. — W. B. PILLSBURY, *The Fundamentals of Psychology*, p. 242

3. A train of associated ideas, each one suggesting the next by a process which travels directly from one sensory center to another, rests . . . on a train of movements each of which, by the kinæsthetic excitations its performance produces, sets the next one off, while delays in the process bring about in sensory centers that have formerly discharged into the motor centers now partially excited, the processes on which the images are based.— MARGARET F. WASHBURN, *Movement and Mental Imagery*, p. 33

4. Our rich inheritance of connections between sense stimuli and mental states, sense stimuli and acts, and mental states and acts is in sharp contrast to our utter poverty with respect to connections between one mental state and another. Nature gives only the general capacity to form such connections as soon as images, feelings of meaning, and judgments have been acquired. One important result of the fact that all purely mental connections are due to nurture is that there is far less uniformity among human beings in the mental-mental than in the physical-mental connections. — E. L. THORNDIKE, *Elements of Psychology*, p. 239

TOPICAL OUTLINE

Physical Bases of Retention
- *A*. General properties of nervous tissue
  - I. Irritability
  - II. Conductivity
  - III. Modifiability
  - IV. Tenacity, or retentiveness

- *B.* Probable conditions and tendencies of nervous tissue of the human brain
    - I. Connections between neurones functional rather than anatomical
    - II. Nervous chains, integration patterns, complexes, etc. formed by synaptic connections between neural fibers
    - III. Functional strength of synaptic connections ranges from nothing to full or complete
    - IV. Motor centers and inhibition
        - 1. Development in pairs, each with opposite functional character
        - 2. Mutually inhibiting and facilitating centers required

Conditions governing the Formation and Retention of Reactions to Concrete Objects: Perceptual and Imaginal Reaction Patterns

- *A.* Objective
    - I. Number of different objects presented in the learning period
    - II. Position of the object in a series
    - III. Rate frequency at which objects are presented
    - IV. Grouping of objects on some rational plan
    - V. Amount of distraction
- *B.* Subjective
    - I. Degree of attention, mental alertness, and interest
    - II. Familiarity and "mental set"
    - III. Freshness, or absence of fatigue
- *C.* Evidences of retention
    - I. Immediate
    - II. Remote
    - III. Forgetting
        - 1. Value
        - 2. Methods for determining rate

Theories of Retention

- *A.* Earlier
    - I. Experience retained as a mental state
- *B.* Later
    - I. Experience retained in the cells of neurones
    - II. Experience retained as a neural predisposition to respond as in its original experience

Recall of Experience

- *A.* Means
    - I. By external stimuli arousing central reaction patterns
    - II. By internal stimuli arousing central reaction patterns
- *B.* Law of association
    - I. Earlier formulation
        - 1. Contiguity
            - *a.* In time
            - *b.* In space
        - 2. Similarity
        - 3. Contrast

4. Secondary laws
    a. Primacy
    b. Frequency
    c. Recency
    d. Vividness

II. Later formulation
1. Contiguity in experience
    a. Temporal relation of the reactions recency, frequency, primacy
    b. Rhythmic presentation of stimuli
    c. Vividness of reaction
2. Combination leading to
    a. Connection of two or more sensory impressions
    b. Connection of two or more motor reactions

C. Difficulties of recall
I. Weak connection between cue and the reaction
II. Inhibitions
III. Disturbance of synaptic connection at centers of response: fatigue, disease, etc.

INTRODUCTION

Retention. The fact that definite concrete experiences are retained from day to day, from month to month, and even from decade to decade is a matter of common observation, and the factors, favorable and unfavorable, involved in the process of retention have been largely determined by experimentation. The results in this field now form a part of the psychology of learning (**26**: 185–186, 294–316; **31**: 334–344).

Such factors as climate, distractions, amount and kind of material to be learned, and the manner of presenting it are termed objective, whereas attitudes, interest, feelings, "mind set," innate capacities, purpose, and education are grouped as subjective conditions, since they form integral factors of the learner. These two sets of conditions apparently control the formation and retention of sense experience. They do not, however, offer an explanation of how and where retention is accomplished, the chief difficulty here being our limited knowledge of the physiology of the brain. But we know enough to assume that retention of sense impressions (for example, perceptions of a picture, of a pound, of a tone) consists in a permanent modification wrought in the cerebral neurones during the

transmission of a nerve impulse from the sensory to the motor brain area. It is assumed that the modifications are registered in two ways: (1) by lessening the resistance offered at the point of contact between neural terminals, the so-called synapse; (2) by leaving in the neural tissues a predisposition to respond in the manner similar to that of the previous responses.

The fact of retention is manifested (1) to an observer by the individual's making reactions which imply the presence of brain modifications persisting from the original or former reaction; (2) to the individual by a consciousness of the former experience or by a reinstatement of the sense perception. The conscious counterpart of the reëxcitation of the neural mechanism is imagery, ideas, and mental complexes of various sorts.

When one is unable to react to absent stimulus, however desirable, or to reinstate it in consciousness, one is said to have forgotten it. Forgetting does not occur in a haphazard manner, but according to an order or law. The rate at which it occurs for different sorts of material has been determined with some degree of accuracy. The methods employed — *recognition* and *saving* — are regarded as standard forms of procedure (**36**: 348–351).

Association. Common experience furnishes examples of the fact that reactions of imagery, whether in memory or in imagination, do not occur alone, separate and isolated, but rather in groups, chains, systems, and complexes. The expression "that reminds me" of social intercourse is an implicit statement that two stories, or two plans, or two incidents, or two or more ideas are in some way connected. Not only images but all forms of coördinated and controlled movements are made possible by the principle of connection or association. The familiar phrases "bundle of habits," "muscle memory," "hierarchy of habits," point to bonds of connection between simpler and separate reaction mechanisms. The first attempt to think about human behavior in a scientific way consisted in formulating laws that would account for the association of ideas. These laws were known as laws of contiguity, of similarity, and of contrast and were so named by Aristotle. The law of contiguity has been ex-

pressed in mental terms thus: "If any two focal states *a* and *l* occur in successive moments of consciousness as impressions, the subsequent recurrence of *a* as impression or idea will tend, under similar marginal conditions, to suggest the recurrence of *l* as an idea" (**19**: 71). The same law may be expressed in neural physiology as follows: When any two or more neurones chance to act together, the resistance offered at the synapses is lessened so that a subsequent excitation of one of the neurones tends more readily to pass over to the second or to others. The law of similarity asserts that two or more sense perceptions, or ideas, not having occurred together or in immediate sequence as original experience but having identical factors, tend to become associated. The law of contrast states that two sense perceptions, or ideas, of the same kind or of the same class, each having a common quality in opposite measure, tend to become associated. The laws of similarity and of contrast are now regarded as special classes of the more general law of contiguity, since both laws depend upon the presence of a neural mechanism common to both terms of the association, the common neural mechanism being contiguous to the two ideas that are associated. "East" and "west" are opposite ideas united by the idea of direction common to both (**1**: 81–93; **2**: 170–175).

The law of combination. 1. *Two or more sense impressions connected by a single response.* The conception of a common reaction mechanism to two or more sense perceptions may serve as a very useful introduction to modern views of the laws of association. Two objects, two events, etc., observed together or in immediate sequence, do not always become associated; the exceptions are too numerous to prove the law. The authors have had playing cards stacked in the same order and distributed by many subjects to compartments from five to ten times a week for a period of from six to ten months without the order in which the cards were stacked ever being learned, although the same order was observed from one hundred and fifty to three hundred times. The order, or series, was learned only when it was made a part of the learning condition. *A*, *B*, *C*, *D*, etc. are

not associated because they have been contiguous *in* experience but because they have been *reacted to as* contiguous experience. Definite, discrete sense impressions, to be connected, must be contiguous in experience and responded to by a single reaction in which both impressions have discharged through the same neural pattern.

2. *Two or more responses connected to the same sense impression.* Coördinate with the principle of associating two or more perceptions, ideas, etc. is that of connecting two or more responses to the same initiating cause. This sort of association is at the basis of habits, skillful movements, and certain phases of thought processes (**36**: 398–414).

Our experiments in reaction time brought out the fact that both simple and compound reaction arcs may be acquired in part by the use of old reflex arcs and in part by perfecting partially formed arcs. It is the existence of partially formed arcs, as well as the presence of multiple synapses of neurones in the brain, which provides pathways through which any arc may establish connections with any other arc. To this physical arrangement of neurones must be added two functional principles: first, that of mind set or purpose; and, secondly, that of neural arcs integrated into larger and larger systems. It is thus possible for one and the same sense impression to arouse two or more simultaneous responses (**8**: 204–205). These responses often show that both innate and acquired reaction arcs have been integrated; for example, the response of surprise with mouth open, eye and forehead muscles arched, and hands thrown up, palms out, shows such an integration. Very often these simultaneous movements are united into higher habits, so-called, for performing definite tasks, such as working a foot pedal and guiding a garment in stitching, or operating a foot press and feeding by hand for printing, or operating a clutch and a brake at a stop signal. When movements are connected in a series for performing a number of successive operations, as in playing a musical instrument, a single stimulus does not suffice to excite them in due order. Professor James, writing on habit, pointed out the principle that doubtless accounts for such

connection. He says: "What instigates each new muscular contraction to take place in its appointed order is not a thought or a perception, but the sensation occasioned by the muscular contraction just finished" (**12**: 140–142). A complex habit may be initiated either by a sensation or by an idea of the action or of the thing to be done, but the succession of movements must be aroused each in turn by the muscle sensation of the muscle contraction immediately preceding.

The laws of association were formulated to account for the connection between the order of ideas in memory, in imagination, and in thinking; they were not applied to the association of movement. We have purposely extended the laws to include the connection between movements in order that the mechanism involved in connecting ideas may be understood. All reaction arcs of sense perceptions and of ideas end in muscular contraction; of course other types of effectors may be involved (as in blushing and in salivation), but in any case the contraction of the striped muscle is dominant. These muscles are provided with sense cells (muscle spindles) which, stimulated by muscle contraction, excite afferent impulses; these new impulses become integrated with contiguous neural processes, aroused, let us say, by the perception of an object. These combined processes excite a second muscular reaction, and this in turn repeats the process of the former by integrating with the next serial perception, and so on. Observe also that such an operation brings together two simultaneous sense impressions: one a sense perception and the other a kinæsthetic impression which by the law of combination first defined (p. 130) becomes united, or connected, by the following muscle response. Thus the kinæsthetic impression reaches back, as it were, through muscle contraction to the previous sense perception and integrates with the next perceptual process. Let us suppose that an individual repeats such a series of perceptual operations until the bonds of association between them become established. Now, in the absence of the objects of perception, it is possible for the individual to reinstate the perceptual experience as a chain of ideas by arousing the first member of the series by either an

external or a central stimulus. The rest of the series will be recalled, in turn, through the mediation of muscular activity. To quote: "The termination of a perceptual reaction can and does stimulate receptors which initiate a new reaction: and reactions which are both initiated and terminated by muscular activities may be linked or associated together almost endlessly" (**8**:300).

The association of ideas is accomplished by two principles: (1) that of contiguous experience, which arranges, as it were, the mechanism to be connected; (2) that of joint reaction, which integrates the mechanism into an association.

Both the temporal order and the vigor of the reactions have been formulated into laws of a subsidiary character. The temporal order of the experience has been expressed by the laws of primacy, of frequency, and of recency, and vigor of the reactions has been described by the law of vividness. These laws have been subjected to considerable experimentation.

The experiments that follow provide opportunity to observe, first, the facts of retention, and, secondly, those of association.

RETENTION OF SENSE IMPRESSIONS

Experiment 54. To study the Effect of the Amount of Subject Matter on Retention (Class Experiment)

Material. Metronome; three series of digits (the first series having five digits; the second, seven; and the third, nine) printed on three cards about 12 in. by 4 in.; tachistoscope; three groups of common objects, such as pencil, knife, comb, thimble, button.

The first group should contain five objects fastened in irregular fashion on heavy cardboard for simultaneous exposure; the second group, seven different objects arranged similarly on a similar card; the third group, nine objects, no one of which appears in either of the other groups, arranged in like manner for exposure. Place the objects behind a screen where they are readily accessible.

Procedure. 1. The metronome beats eighty strokes to the minute. The instructor places the first card of digits in the tachistoscope. The class does not know the number of digits to be exposed. The duration of exposure should be three quarters of a second per digit. Since the strokes of the metronome occur in three-quarter-second

intervals, the time is determined by counting as many beats as there are digits on the card; for example, five digits would require three and three-fourths seconds, or five beats. The exposure is made by lowering the sliding screen until its opening is flush with the front opening and raising it at the end of the count. Each member of the class counts fifteen beats of the metronome and then writes the digits retained in the order in which they were exposed.

2. The objects are exposed for the same duration of time as the digits. After exposure, the subjects count fifteen beats of the metronome and then write the names of the objects as seen on the card.

Results. *Subject's report.* The instructor calls off the groups of numbers in the order of exposure, and subjects check and score their lists. A digit misplaced counts half. Deduct 1 for the insertion of a wrong digit. The groups of objects are scored in like manner. The results for both digits and objects are arranged in tabular form on the blackboard, showing the actual number exposed, the number retained, the averages, and the mode for the class.

NOTE. This experiment may be repeated by presenting to the ear a new set of numbers and the names of a new set of objects.

Discussion of results. Why is it necessary to count after each exposure before writing the amount retained? What efforts were made to retain the stimuli? To what extent does the number of separate impressions affect the amount retained? Why is retention higher for the objects than for the numbers? Has the subject any evidence which the instructor or others do not have that he retains the impressions of the objects, and if so what term is applied to it?

Inference. Make a general statement in the form of a law.

READINGS. **18**: 148–149; **21**: 371; **28**: 383; **33**: 155–162.

EXPERIMENT 55. To study the Effect of Time Order of an Object in a Relatively Short Series on the Amount of Retention (Class Experiment)

Material. Metronome; a series of nine digits and one of nine nonsense syllables.

Procedure. 1. At a signal the instructor reads the series of digits in a uniform tone at the rate of one in three quarters of a second, as marked by the metronome beats. At the end of the reading, the subjects silently repeat the alphabet from *a* to *m* to the beats of the metronome, after which they write the digits in the order read.

2. A similar method is used for the nonsense syllables, but this list should be read twice.

Results. The instructor writes on the blackboard the digits and the nonsense syllables as read. The subjects score their results by the series as written. Then the instructor determines for each digit and for each nonsense syllable, respectively, the number of subjects who retained it correctly. The digit must be correct in form and position in order to be counted; this being reported to the instructor by the individual student. The same rule applies to the nonsense syllables, after making exceptions for phonetic mistakes (for example, if "pur" was spelled "per" it is counted). The results given below were obtained from a class of twenty-four, the number indicating the correct record for each digit or syllable being written as an exponent, thus:

Numbers	7^{23}	9^{24}	6^{20}	2^{14}	5^{6}	1^{4}	4^{11}	8^{18}	3^{22}
Syllables	pur^{12}	gud^{17}	tig^{2}	muz^{0}	ric^{1}	mul^{0}	kak^{6}	rin^{8}	hud^{11}

Discussion of results. Why is a larger number of impressions retained at or near the beginning and the end of the series respectively? Why is the number of digits retained in excess of the number of syllables? Why would not words do as well as digits or syllables?

The number of digits in the list is slightly in excess of the scope of apprehension, and the number of syllables considerably so. What would be the probable effect on the amount retained of adding one third more digits to the list?

Devise a class experiment with the use of the tachistoscope to study the same laws of retention for visual impressions.

Inference. Express the results in the form of a law.

READINGS. **4**: 152–158; **18**: 149–150; **25**: 86–114; **33**: 72–73; **36**: 376–381; **38**: 304–306.

EXPERIMENT 56. To study the Effect of the Rate of Receiving Sense Impressions on the Amount of Retention (Class Experiment or Two Students)

Material. Metronome; tachistoscope; a roll of adding-machine paper 8.8 cm. wide; rubber type, 2 cm. high and 4 mm. wide, of digits and letters.

If the experiment be assigned to students in pairs, E and S, then apparatus shown in Fig. 17 may be used. This figure is the end view of the same apparatus as shown in Fig. 16. The same size adding-

machine paper strips and same type of printed matter as described above can be used in the exposure slits shown in the upright. These slits are 1 cm. in height and 10 cm. in horizontal width. The lower slit is 30 cm. from the baseboard.

If the work is done by the class and directed by the instructor, then use the tachistoscope (Fig. 15) as described in Experiment 49, *B*. Cut from the adding-machine paper eighteen strips 110 cm. long. Print on each of six strips a different series of ten two-place numbers 6 cm. apart; on each of six similar strips print a different series of ten four-letter words; finally prepare a third set of six in the same manner, composed of ten nonsense syllables each. Place on the reverse side of the strips, opposite the numbers, syllables, or words, a black band that will indicate to E the position of the object to be observed. (If a Jastrow exposure apparatus is used, eighteen cardboards, 35.5 cm. by 16 cm., should be prepared for receiving the numbers, words, etc.)

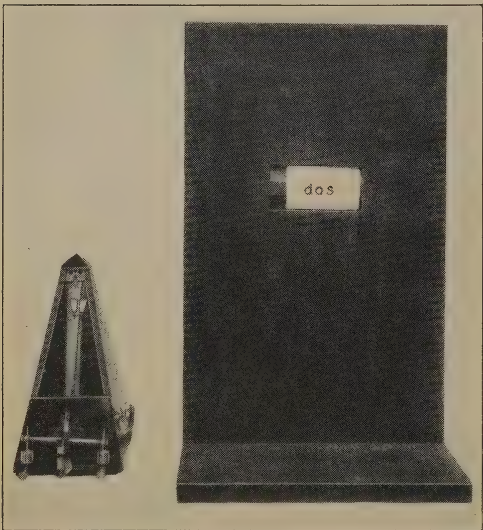

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FIG. 17. Small tachistoscope

Procedure. 1. Set the metronome to beat one hundred and twenty strokes per minute. E threads a strip bearing numbers in the slits of the tachistoscope. At a signal "Ready" E pulls the paper strip at each beat of the metronome, thereby exposing a number at the rate of one every half second. At the end of the exposure, S silently counts twenty strokes of the metronome and then records all the numbers retained. E then calls out the ten numbers so that S may correct and score his lists. Numbers with digits reversed count a fourth; digits in wrong positions count half; 1 is deducted for inserting a wrong number. A similar procedure is repeated with a second strip containing numbers, and the score is determined as before. Then the same procedure is applied to two strips bearing words of

four syllables. In scoring, 1 is deducted for every false word, and a word in the wrong position counts half. Finally, the two strips bearing the nonsense syllables are treated similarly.

2. Set the metronome to beat seconds. E exposes in turn, as in part 1, two strips bearing numbers, two bearing words, and two bearing nonsense syllables. The results are scored as above.

3. Set the metronome to beat once in two seconds. Then E exposes a third series of numbers, words, and syllables as in parts 1 and 2. The score is computed as before.

Results. Experimenter's report. Prepare a table according to the following form:

TABLE XXII. RELATION BETWEEN LENGTH OF EXPOSURE AND AMOUNT RETAINED

STIMULUS	HALF-SECOND EXPOSURE		ONE-SECOND EXPOSURE		TWO-SECOND EXPOSURE	
	Average	Mode	Average	Mode	Average	Mode
Numbers						
Words						
Nonsense syllables . .						
Final average . . .						

Each student averages his three scores in each of the three rates of exposure for the numbers, words, and syllables. Then the average and the mode for the entire class should be computed and arranged as in Table XXII. The table might also show the highest and lowest scores made in each of the three kinds of stimuli.

Discussion of results. Ascertain from the literature the records for rapid, medium, and slow readers. Is the amount of retention for a given stimulus affected more by rate of exposure than by individual differences? Which rate appears the most favorable for retention? What reasons can you assign for this? How do you account for the greater retention of words? Does this hold true for the different rates?

Inference. Express the law of retention in relation to the rate of receiving impressions.

READINGS. **21**: 378–379; **28**: 403–404; **33**: 70–72; **34**: 160.

EXPERIMENT 57. Classification and Retention (Class Experiment)

NOTE. The purpose of this experiment should not be stated until after the results have been secured.

Material. Two lists of sixteen words each. Let the words of the first list be, for example, the names of tools on a farm, as "reaper," "hoe," "rake," etc., and of the dairy products, as "cheese," "milk," "butter"; and let the words of the second list be, for example, the names of objects kept in a hardware store and in a drug store.

Procedure. The character of the words in the first list is not stated to the class. The instructor reads in a uniform tone at the rate of two words per second, after which the subjects count for ten seconds and then record as many of the words as possible. Before reading the second list, the instructor explains to the class that the words may be recorded under two general classes (for example, drug-store names and hardware-store names), and that they should thus classify them as they are heard and record them accordingly after they have counted for ten seconds.

Results. Compute the percentage of retention in each of the two lists of names, and record words and percentages in a table.

Discussion of results. Was there any special bodily movement observed as you recognized a name belonging to one or the other of the two classes? Did the fact of classification distract you at any time? Why does classification increase the percentage of retention? (See page 128.)

Inference. State in the form of a law the relation that exists between retention and classification.

READINGS. **18:** 167–168; **21:** 397–398; **24:** 243.

EXPERIMENT 58. To study the Effect of Different Degrees of Meaning in the Stimulus on the Amount of Retention (Class Experiment)

Material. Stop watch; four lists of words: (1) sixteen words in logical connection (for example, "the success of this plan makes it possible for Congress to adjourn for the holiday season"); (2) sixteen words with no apparent logical connection (for example, "beech," "valley," "apple," etc.); (3) sixteen suffixes and prefixes (for example, "cle," "pre," "sub," etc.); (4) sixteen nonsense syllables, to be prepared by the instructor.

Procedure. The instructor reads the sentence twice in a uniform, even tone. At the close of the second reading the class count for twelve seconds as timed by the instructor. He gives the signal "Write" at

the end of the twelve seconds, and the class at once reproduce the sentence. This procedure should be carefully followed also with the three other lists, — separate words, suffixes and prefixes, and nonsense syllables. Each series is read twice at the rate of a word or syllable every three-fourths second. The results of the class for each series are checked as soon as they are reproduced. To avoid errors in checking the results the series may be written on the blackboard.

Results. *Subject's report.* Make a summary of the methods employed for retaining the impressions.

Experimenter's report. Construct a table according to the form given in Experiment 56, indicating the kinds of stimuli in a vertical column at the left, and recording the following data in the other five columns, under the following headings: (1) the highest number retained by any member of the class, (2) the lowest number retained by any member, (3) the average number for the class, (4) the mode, (5) the average percentage.

Discussion of results. What enabled you to retain the words of the sentence (see page 128)? Did you adopt a method for retaining the words of any of the series? Which series, aside from the sentence, offered the greatest inherent aid? Is the mode or the average the better measure of the amount of meaning in a series? Can you devise a method for measuring the amount of meaning in words for an individual?

Inference. Express the law of the relation between meaning and the amount of retention.

READINGS. **3**: 43; **21**: 397–401; **22**: 147; **24**: 235–236; **38**: 309–310.

EXPERIMENT 59. To study Retention, Mental Alertness, and Anticipation (Group Experiment)

Material. Stop watch; screen board; two charts 16 in. by 20 in., each bearing a different set of sixteen characters, selected, arranged, and known only to the instructor (or two different sets of sixteen objects each, known, of course, only to the instructor, may be arranged on a table covered with a suitable screen).

Procedure. The instructor asks about half the members of the class to withdraw from the room and explains to those remaining that there are such and such objects arranged in a certain way on the cardboard or on the table. He is specific as to the number, the kind, and the nature of the arrangement of the objects. At a given signal the screen is removed and the objects are exposed for twelve seconds,

at the close of which the subjects count silently for twelve seconds and then proceed to write or draw the objects, — writing or drawing depends on the nature of the objects. The other half of the class now returns to the room and observes the same objects under similar conditions, but without any explanation whatsoever as to the nature and arrangement of the stimulus. Each member of the class counts for twelve seconds before recording the impressions. Repeat the procedure, using the objects on the second cardboard. This time the groups should exchange places, those who remained in the room before being the ones to withdraw.

Results. The results of the class are tabulated under two headings: "With Anticipation," "Without Anticipation." The table should show the number of objects reproduced under each condition, the average, the mode, the highest and the lowest number of impressions retained under the respective conditions.

The students of both groups should state whether mental alertness operated under the conditions in which they worked.

Discussion of results. Describe the effect of preperception in terms of bodily behavior; in terms of consciousness. What is the psychological value of an aim in a recitation? of an introduction to a book or a lecture? What is the quantitative effect, according to experiment, of preperception on retention? (See pages 128–129.)

Inference. State briefly the relation between preperception and retention.

READINGS. **4**: 161; **12**: 262–264; **24**: 231–232; **36**: 74–77.

ASSOCIATION OF SENSE IMPRESSIONS AND IDEAS

The time relations of mental processes, including those of association, were studied in connection with the problems of reaction time. There remain for study the nature and causes of the connections between discrete, implicit mental states.

EXPERIMENT 60. **To observe Laws of Contiguity (Contiguity-Similarity, Contiguity-Contrast) and Laws of Combining Sense Impressions and Motor Responses (Two Students)**

Material. Key words; stop watch; writing material.

Procedure. At a signal E calls out a key word (stimulus) and S records as rapidly and as fully as possible ideas which are suggested by it. To save time in recording the suggested associations abbreviate

the words. Write for twenty seconds. Repeat twice, using a new key word each time.

Results. Experimenter's report. Record the key word at the left of the page and the associated words in a horizontal line at the right. Then study the list carefully with a view of detecting the probable law by which the connection was made in any case. The following report shows the correct form:

Key Word	Associated Words
chair	stool + floor + desk + hair + ceiling + plaster + stucco + art + Raphael + Italy + Garibaldi + rebuke

Discussion of results. "Chair" suggested "stool" by contiguity-similarity of function. Both "chair" and "stool" suggested "floor" by contiguity, as both are supported by it. "Desk" was associated with "chair" by sensory combination, and the same applies to "hair," for by this time "chair" meant a barber's chair, which suggested hair on the floor of the barber shop (but no particular shop). "Ceiling" came by contiguity-contrast to floor. "Plaster" was associated with ceiling by sensory combination; "stucco" grew out of "plaster" through contiguity-similarity of material and of function (both cover up woodwork). "Art" was associated with "stucco" by contiguity. "Raphael," "Italy," "Garibaldi," were each in turn connected by contiguity. The same law applies to "rebuke." S had recently read an account of an interview with General Garibaldi in which he severely rebuked America for not protesting against Germany's invasion of Belgium.

But why did "Raphael" and not "Rosa Bonheur" follow "art" and why did "Garibaldi" and not "Dante" follow "Italy"? Such cases call for a further analysis of the conditions governing associations (see discussion in Experiment 61).

Inference. Formulate the laws of contiguity and of similarity.

Readings. **6**: 160–168; **10**: 283–285; **21**: 246–253; **23**: 118–125.

Experiment 61. To study the Secondary Laws of Association (Two Students)

Material. Stop watch; key words that will be most likely to bring to mind S's experiences; for example, "vacation," "fight," "1492," "movies."

Procedure. At the signal "Ready" E pronounces a key word and starts the stop watch, and S records the free associations in an abbreviated fashion for fifteen seconds.

Results. Subject's report. Write out the chain of associations after the form given in the preceding experiment and then proceed to work through the list, comparing the associated terms with such pertinent parts of your own experience as will determine the probable secondary laws that operated in each instance to cause the association; for example:

Key Word	Associated Words
breakfast	late + cereals + sausage + burnt + gas flame + stove + Zenith Furnace Co. + coke oven + light + inferno + Dante

Discussion of results. "Breakfast" suggested "late" because that meal had been served later than usual for several days (law of recency). "Cereals" appeared next, being the usual first dish for breakfast (law of frequency). "Sausage," too, followed "breakfast," rather than "cereals," by the law of recency, because fresh country sausage had been served on two previous mornings. "Burnt" popped up next, owing to the laws of vividness and recency; the sausage had been overcooked and when served made not only an intense stimulus to the senses of smell, taste, and vision but provoked a vigorous reaction. A second or more of blankness occurred here, broken by the appearance of a visual image of a feeble gas flame (the law of recency). On the previous day the subject had observed an inconstant gas flame due to the irregular flow of gas. "Gas flame" suggested "stove" (frequency), which in turn brought out "Zenith Furnace Co." by the law of primacy. The stove had been purchased ten years before from that company. "Coke oven" followed "furnace" (frequency). The imagery of light aroused by "coke oven" resembled so-called sheet lightning at first but changed instantly into leaping tongues of fire and lurid smoke (vividness). "Inferno" was associated with "coke oven" (frequency) rather than with "light"; the subject never sees nor images a coke oven without thinking "inferno" or "hades." "Dante" popped up by the law of frequency.

Practice in detecting the operation of the secondary laws is recommended as an exercise for the individual. A key word may be found by taking the first word the eye chances to see upon opening a book, and then recording the associations that follow for the next thirty seconds. Work through the chain of associations word by word by means of introspection, comparing and checking each with the experience upon which they are based.

EXPERIMENT 62.[1] To study Quantitatively the Secondary Laws of Association (Group Experiment)

NOTE. This is a modification of the original methods devised by Professor Mary W. Calkins in her study of the secondary laws of association. Groups of twenty to twenty-five may perform this work at the same time.

Material. Metronome or stop watch; tachistoscope (see Fig. 15); ten series of nonsense syllables. Number the series from I to X.

Prepare ten strips of paper, each 110 cm. long, cut from a roll of adding-machine paper 8.8 cm. wide. Print upon each strip ten nonsense syllables, each syllable paired with a number of two digits, taking care that no syllable or number is repeated on any two slips. The letters are printed from rubber type and should be at least 2 cm. in height and 0.5 mm. in width. Leave a space of 6 cm. between the syllables. Repeat the series of nonsense syllables just below the paired columns of syllables and numbers, as indicated in the lists below. The series given here (modified from Starch) serve as samples from which the ten series may be constructed. It will be observed that the first series is designed to reveal the operation of the law of *frequency* and the second the law of *vividness*. Of course *primacy* and *recency* are shown in each series by the first and last pairs.

SERIES I

mem . . .	27
maj . . .	18
ber . . .	86
tum . . .	22
dod . . .	57
gif	14
ber . . .	86
riz	63
boc . . .	51
wac . . .	74

boc
riz
ber
wac
mem
maj
tum
dod
gif

SERIES II

cim	73
muk . . .	36
gam . . .	18
WUD . . .	42
lum	95
tir	64
ret	82
caw	29
ulk	32
zon	58

ret
tir
cim
zon
wud
caw
ulk
gam
muk
lum

Procedure. The students are seated in front of the tachistoscope. The instructor threads the tachistoscope with strip bearing Series I and, at a signal, exposes a syllable and its number for three seconds; allowing two seconds to intervene before exposing the next pair. This is continued until the ten pairs are exposed. The class is instructed to pronounce silently both the syllable and the number. The syllables of the test series are now exposed at the same rate, and the class writes the number corresponding to the syllable as it is exposed. Proceed similarly with the other nine series, allowing an interval of at least two minutes between the successive series.

Results. The instructor should suspend the ten strips bearing the ten series before the class, so that each member may check off the number and kind of correct associations. Since there are ten series, it is possible to have ten correct associations each for primacy and for recency. But since only the odd series present conditions for frequency, and only the even series conditions for vividness, it is possible to form only five correct associations each for frequency and vividness. Finally, there is left a possible sixty-five cases for miscellaneous associations. In determining the per cent of associations, 10 becomes the base for primacy and recency, 5 for vividness and frequency, and 65 for miscellaneous associations. The following table is based upon the results obtained from ten subjects:

TABLE XXIII. RESULTS FOR SECONDARY LAWS OF ASSOCIATION

Series	Number of Correct Associations				
	Primacy	Recency	Vividness	Frequency	Miscellaneous
I	7	2	2	2	14
II	5	3	4	2	19
III	6	5	4	2	25
IV	6	6	2	4	25
V	5	3	2	3	20
VI	6	4	3	3	19
VII	2	4	1	5	20
VIII	2	3	0	5	20
IX	6	0	2	3	19
X	2	2	3	1	7
Averages	4.7	3.2	2.3	3.0	18.8
Percentages	47	32	46	60	28.9

Discussion of results. If the percentage of the miscellaneous associations should be higher than that of any of the others, what inferences might be drawn about the conditions of the experiment?

Show how the laws of combination and contiguity operated in this experiment (see page 130). If muscular contraction occurred, what muscles were used? Did this contraction aid in forming the associations? How? Which set of conditions do you think demonstrates more rigidly the four secondary laws of association, that of Experiment 61 or that of Experiment 65? (Answer after performing Experiment 65.) Make a list of your memories, illustrating each one of these four laws. Does your own experience corroborate the adage "First impressions last longest"? What conditions give rise to the law of primacy? of recency? of frequency? Mention some practical application of these laws useful to the public speaker; the salesman; the teacher; the lawyer; the student.

READINGS. 7: 149–154; 12: 264–267; 17: 160–169; 25: 86–114.

ASSOCIATION REACTION AS A MEANS OF DIAGNOSIS

The primary and secondary laws of association are reputed as universal in validity and point to a commonalty of human behavior. They give no indication of the mind's individuality or even of types and of attitudes of mind. The remaining experiments in association are designed to reveal types, emotional complexes, *community* of ideas, individuality, and the nature of logical association. The methods here seek individual and differential results rather than laws of universal validity.

EXPERIMENT 63. To study Individuality in Free, Continuous Association (Two Students)

Material. Stop watch or clock with second-hand; blank forms containing fifty numbered spaces.

Procedure. At a signal agreed upon E starts the stop watch and S begins to say words aloud, beginning with any chance word, as fast as possible until fifty are given. E writes the associated words in an abbreviated form on the prepared blanks and stops the watch at the end of the fiftieth response. S is cautioned to respond in words and not in phrases or sentences, also to refrain from responding to perceived objects, seen or heard. The abbreviated record is completed by E and S together. E and S now exchange places, and fifty more responses are made in the same manner.

Results. *Subject's report.* Each subject studies his own list and classifies the words under the following headings: (1) Perceived

Objects, those of both sight and sound perceived during the trial (critical inspection may show responses to perceived objects); (2) Alliterative Words, as "rip," "ripe," "rope"; (3) Riming Words, as "some," "plum," "dumb"; (4) Pivotal Words — for example, in the list "floor," "rug," "carpet," "mat," "gym," "class," "play," "game," "sport," "variation," "heredity," the words "floor" and "sport" stand at turning-points in the series and give rise to a number of associations, each connected with a common theme; (5) Abstract Nouns; (6) Proper Nouns; (7) Common Nouns; (8) Miscellaneous. The individual records should show the number of words classified under each heading.

Experimenter's report. Record the time required by S to write the fifty association words.

Arrange the results of the class in a table of eight columns with the headings given above, the subjects' names at the extreme left, and the time for each subject at the extreme right, the median and average time being determined for the group.

Discussion of results. Compare your time for making the fifty associations with the median and the average of the class. Do you regard yourself a slow, a medium, or a rapid thinker? Are you a rapid talker? In which of the above groups do the larger number of your words fall? Why? Do your words fall under the exceptional headings or in those that are common? How do you interpret that fact?

If possible, secure fifty associations under the conditions of this experiment from children of nine, twelve, and fifteen years of age, respectively. How do you account for the wide differences in time?

READINGS. **23**: 118–126; **33**: 44–53.

EXPERIMENT 64. To observe the Extent of Community Ideas by Discrete, Free Associations (Group Experiment)

Material. Metronome; strips of paper with fifty ruled spaces; a list of fifty common words, nouns predominating.

table	black	sweet	rough	high
dark	mutton	whistle	citizen	working
music	comfort	woman	foot	sour
sickness	hand	cold	spider	earth
man	short	slow	needle	trouble
deep	fruit	wish	red	soldier
soft	butterfly	river	sleep	cabbage
eating	smooth	white	anger	hard
mountain	command	beautiful	carpet	eagle
house	chair	window	girl	stomach

The list is here printed upside down to prevent the student's gaining familiarity with it. Similar lists may be selected from Kent and Rosanoff's "A Study of Association in Insanity" (15: 77–123).

Procedure. E pronounces the key words as distinctly as possible at the rate of one every fourth second. To secure exactness in time E counts silently "one," "two," "three," with the beats of the metronome, and instead of counting the fourth beat pronounces the key word; counts again "one," "two," "three," etc., until the fifty words are pronounced. S records at once the word (phrases or sentences that pop up are ignored) suggested by the key word.

Results. Two members of the class should compile the results and report for discussion at a subsequent hour. The suggestions and examples given here may aid in preparing a report. Arrange the associated words in alphabetical order. The following tables and histograms express the results of twelve subjects responding to the fifty words presented above; twenty-five or thirty subjects would require more elaborate tables. Since twelve responses were made to each word, they might all be different, or all alike, or part alike and the rest different, or again there might be two sets of frequencies, a higher and a lower, and the rest be different; for example, "sweet" brought "sugar" five times, "sour" four times, and three different responses. The number of community responses made to a word may be expressed by letters, using *O* for different responses and *A*, *B*, *C*, etc., respectively, for seven, six, five, etc., similar responses. Number the subjects and place their numbers on a horizontal line at the top of the table as given in Table XXIV.

TABLE XXIV. FREQUENCY OF COMMUNITY RESPONSES, INDIVIDUAL RESPONSES, AND COMMONALTY OF WORDS

WORD NUMBER	SUBJECT'S NUMBER												SUMMARY					
	1	2	3	4	5	6	7	8	9	10	11	12	7	6	5	4	3	*O*
1	*B*	*O*	*B*	*B*	*B*	*O*	*O*	*O*	*O*	*B*	*B*	*O*		*B*				6
2	*A*	*A*	*A*	*A*	*A*	*A*	*O*	*O*	*O*	*O*	*A*	*O*	*A*					5
3	*O*	*B*	*B*	*O*	*B*	*O*	*O*	*O*	*B*	*B*	*O*	*B*		*B*				6
4	*E*	*C*	*E*	*E*	*C*	*O*	*O*	*O*	*C*	*C*	*O*	*C*			*C*		*E*	4
.																		
.																		
.																		
50	*O*	*E*	*O*	*E*	*O*	*E*	*O*	*C*	*C*	*C*	*C*	*C*			*C*		*E*	4
Community responses	23	32	33	30	20	23	13	21	17	19	21	17						
Different responses .	27	18	17	20	30	27	37	29	33	31	29	33						

The numbers corresponding to the key words appear in a vertical column at the extreme left. The letter symbols signifying number of community responses are placed at the right of the number of the key word under each subject's number. The summary to the extreme right is given in letters; for example, to the fourth word, *C* (5) responses were similar, *E* (3) were alike, and *O* (4) were different. The totals in horizontal lines at the bottom of the table show the community and different responses of the subjects to the fifty words; for example, subject number 2 shows a commonalty of 32 responses, or 64 per cent, while subject number 12 shows only 17 responses, or 34 per cent. Two frequency distribution tables, based on results of the table, are here constructed. Histograms[1] are drawn from each of the frequency tables and are intended to express the range and amount of commonalty and individuality, respectively. If desired, a distribution table may be constructed from lower and higher frequencies of commonalty.

Table XXV. Distribution of Community Responses to Fifty Key Words

9 words received 2 similar responses
11 words received 3 similar responses
12 words received 4 similar responses
7 words received 5 similar responses
5 words received 6 similar responses
3 words received 7 similar responses
1 word received 8 similar responses
1 word received 9 similar responses
1 word received 10 similar responses

Table XXVI. Distribution of Individual Responses to Fifty Key Words

1 word received 3 different responses
1 word received 4 different responses
3 words received 5 different responses
6 words received 6 different responses
7 words received 7 different responses
11 words received 8 different responses
7 words received 9 different responses
6 words received 10 different responses
7 words received 11 different responses
1 word received 12 different responses

[1] A histogram is a graphic representation of a frequency distribution by means of a frequency surface divided into rectangles.

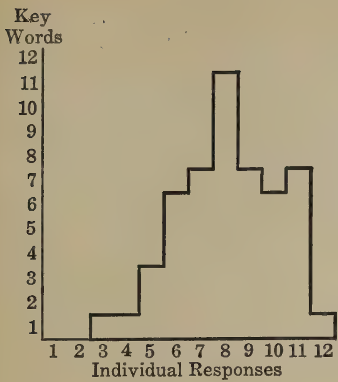

FIG. 18. Histograms, showing comparative number of individual and community responses to common words

Discussion of results. Compare tables and corresponding histograms to decide which is the greater, responses of individuality or those of commonalty. Examine the words and the amount of commonalty in class results with a view to finding factors that tend to promote common responses. Why should a word like "trouble" arouse no similarity of responses when one like "foot" received the same response in 75 per cent of the cases? Does the per cent of your frequency responses rank you as tending toward commonalty of your class or away from it? Would stimuli designed to arouse feelings show comparatively more or less commonalty? Justify your answer.

Inference. Summarize the main facts in a few statements.

READINGS. **13**: 219–269; **15**: 5–15, 16–30; **34**: 44–67; **35**: 24–110; **37**: 9–79.

EXPERIMENT 65 A. To study Controlled or Logical Associations involving the Relation of Opposites (Two Students)

NOTE. Because of the length, as well as the varied aspects, Experiments 65 A to 65 E will require two or more class periods. E and S should exchange places at the completion of each exercise.

Material. Stop watch or Sanford's chronoscope; sheets of paper with twenty numbered blank spaces for recording the key word, the stimulus, and the time; two lists of twenty key words each for easy opposites and two similar lists for difficult opposites (each list may be printed on a strip of paper, or each word may be printed on a small card).

Easy Opposites		Difficult Opposites	
List I	List II	List I	List II
good	up	absent	succeed
outside	wet	best	strict
quick	new	false	tardy
white	soft	first	sleepy
light	wrong	glad	suspicious
rich	yes	less	rigid
empty	young	like	miser
war	winter	loud	innocent
many	weak	noisy	loud
hot	forget	nowhere	despondent
dirty	wild	raise	beautiful
heavy	straight	sick	busy
late	love	stale	tender
left	day	stay	haughty
near	asleep	thin	hindrance
north	brother	apart	push
in	big	generous	crazy
east	come	refined	preserve
something	broad	silly	belief
high	dead	vertical	sell

These sample lists of easy and difficult opposites may be used if they have not been observed by S.

Procedure. E gives a "Ready" signal; then starts the stop watch and pronounces the key word simultaneously, and stops the watch when S responds with a word whose meaning is opposite to that of the key word. The time is recorded in tenths of a second, together with the key words and response words. As soon as the first list of easy opposites is finished, E and S exchange places and proceed with the second list of easy opposites. Impress upon S that the exact opposite is required in the response and that no other will be accepted. Proceed similarly with the difficult opposites.

Results. *Subject's report.* Give the characteristic movements and attitudes observed as the response with an opposite word is made and also any tendency to respond with synonyms or with the key word.

Experimenter's report. Inspect both easy and difficult opposites for errors. After eliminating erroneous trials, compute the medians and the averages of each list.

Discussion of results. How may the relatively short association time of opposites be accounted for? What is the element of similarity that exists in opposites?

If your observations are not clear, repeat the experiment with ten different words having opposites, and note bodily movements, etc.

Why does one often say "west" when he intends to say "east"? Can you give other practical examples of opposites?

Inference. Place the inference at the end of Experiment 65 E and let it include what has been learned from the results obtained in Experiments 65 A to 65 E, inclusive.

Experiment 65 B. To study Controlled or Logical Associations involving the Whole-Part Relation (Two Students)

Material. Stop watch or Sanford's chronoscope; numbered blanks for recording the results; two lists of twenty words each.

List I		List II	
apple	chair	wagon	gun
clock	bird	store	eye
knife	banana	factory	ocean
book	shoe	ship	forest
hat	carriage	tree	kitchen
pencil	house	county	school
hand	coat	engine	river
dog	piano	city	eagle
oyster	desk	bee	melon
church	horse	sheep	desert

Procedure. The same procedure as in Experiment 65 A is followed, except that S responds with a word that names a part of, or an object included in, the whole as named by the key word; for example, E pronounces "table," to which S responds "top," "caster," or "leg." Require S to state after each response if the response word was chosen from among several possible responses after some hesitation, or if it came alone and without effort. Call the former responses rational and the latter habitual; for example, "lamp" as key word aroused "chimney," "wick," "oil" (the visual image of oil in the glass bowl was chosen and expressed), but when "hat" served as the key word "brim" appeared at once, alone and as vocal motor, an example of a habitual response.

Results. Subject's report. Concerns conflicts between secondary (Exp. 62) and part associations etc.

Experimenter's report. Compute the average, median, mode, and M.V. of the rational and habitual responses respectively.

Compare the time for the opposite reaction with that for the part-whole reaction.

EXPERIMENT 65 C. To study Controlled or Logical Associations involving the Subordinate Relation (Two Students)

Material. Stop watch or Sanford's chronoscope; sheets of paper having twenty ruled blank spaces; two lists of twenty words each.

LIST I		LIST II	
flower	star	color	fruit
machine	plant	holiday	disease
mineral	novel	fish	grain
season	hospital	tool	drink
century	meat	religion	month
state	history	vegetable	ocean
judge	furniture	coin	language
war	live stock	city	lake
school	magazine	insect	newspaper
automobile	wine	food	tree

Procedure. The procedure is the same as in Experiment 65 A, except that S responds with an associated word that names a subclass in the family named by the key word; for example, E pronounces "feline" and S responds "tiger." Let the record show key word, associated word, and the time.

Results. Subject's report. Compare inhibitions and readiness to respond with those of Experiment 65 B.

Experimenter's report. Compute the average, median, of the rational and habitual responses respectively. Compare the two medians of this experiment with the medians of similar quantities in Experiment 65 B. Compare your results with those of other members of the class.

Discussion of results. Account for the tendency of the medians in the rational and the habitual responses involving subordinate relation to be smaller than those of the whole-part relation. Compare the number of rational responses with that of the habitual in both Experiments 65 B and 65 C, the former responses being words suggested by the conditions of the experiment or otherwise, the latter by force of habit; for example, century — twentieth.

EXPERIMENT 65 D. To study Controlled or Logical Associations involving the Relation of Synonyms (Two Students)

Material. Stop watch or Sanford's chronoscope; two strips of paper with twenty ruled blanks; two lists of twenty words each similar to the lists given on page 153.

List I		List II	
forsake	decide	wretched	bring
able	console	rich	haste
moisture	dismay	stupid	speed
impatient	dispute	mirth	idle
pretty	enough	change	famous
brink	engage	suspend	awful
crush	error	grasp	conceal
caress	gain	earnest	consign
cheap	free	invent	pitiful
conceal	gaudy	blame	content

Procedure. E starts the stop watch, after giving the "Ready" signal, and at the same time pronounces the key word distinctly, and S responds to the key word with a synonym. S must not respond until he is sure that he has the correct synonym. Guessing is not allowed. As soon as the first list is finished, E and S exchange places and proceed with the second list. As in Experiments 65 B and 65 C, S reports whether the synonym appeared spontaneously after the manner of a habitual response or whether it appeared with effort. S also reports when two or more synonyms appear, necessitating a choice.

Results. Subject's report. Describe increased difficulties and inhibitions encountered.

Experimenter's report. Compute the average, median, and the M.V. for the twenty responses. Observe the irregularity of the reaction time.

Discussion of results. What characteristics belong to the key words whose synonyms appear with much effort? What explanation can you offer for the spontaneous appearance of the synonyms? Does your explanation refer to the subject or to the key words? Is there a direct correlation between the time responses with synonyms and scholarship? How should you investigate such a problem? What experiment have you performed in which the associations roughly contrast with those of the present report?

Experiment 65 E. To study Controlled or Logical Associations based upon Similarity of Relations (Two Students)

Material. Stop watch or Sanford's chronoscope; two sets of words expressing similar relations, each set consisting of twenty parts of four words each, three of which are expressed and one required; two strips of paper with twenty ruled blanks.

Set I	Set II
ant : nest :: bear : ?	hungry : food :: thirsty : ?
he : him :: she : ?	pump : water :: heart : ?
cashier : bank :: brakeman : ?	horse : wagon :: engine : ?
begin : end :: start : ?	iron : mine :: oil : ?
April : May :: summer : ?	island : ocean :: oasis : ?
day : week :: month : ?	England : London :: France : ?
cat : mouse :: hawk : ?	shingle : roof :: carpet : ?
eat : bread :: drink : ?	nephew : niece :: uncle : ?
face : wash :: floor : ?	oyster : shell :: banana : ?
shoe : mend :: sock : ?	noun : adjective :: verb : ?
fish : water :: bird : ?	chicken : coop :: cow : ?
gas : burn :: ice : ?	chew : teeth :: smell : ?
house : room :: book : ?	fire : smoke :: water : ?
hen : rooster :: goose : ?	hip : leg :: shoulder : ?
Indian : canoe :: sailor : ?	thumb : nail :: head : ?
pen : ink :: brush : ?	foot : yard :: quart : ?
mortar : trowel :: nail : ?	messenger : telegram :: postman : ?
shovel : dirt :: ax : ?	brick : mortar :: bread : ?
bow : arrow :: bat : ?	doctor : patient :: lawyer : ?
tobacco : cigar :: leather : ?	deer : fawn :: cow : ?

Note that in the lists given each set is composed of twenty pairs of words and with each pair is a third bearing the same relation to a fourth word as the first word does to the second. For E's convenience in giving the experiment the three words constituting the stimulus may be written on a small card.

Procedure. E acquaints S with the nature of the experiment by giving several preliminary instances; for example, E might say, "Soil is to plant as food is to what?" implying that the relation of soil to plant is the same as that of food to animal. E starts the watch at the same time that he pronounces the third word, in this instance "food." S responds as soon as possible with a word standing in the same relation to the third as the second stands to the first. E must adhere to the same formula of presentation and maintain the same tone of pronunciation throughout. The following formula is recommended after the "Ready" signal: "Penny is to copper as nail is to what?" or "Dog is to canine as trout is to what?"

Results. Subject's report. Describe the bodily conditions before the second word of the four terms is pronounced; after the third word is pronounced.

Experimenter's report. Compute the average, median, and the M. V. of the reaction times and compare them with similar quantities obtained for the entire class.

Discussion of results. What condition did the body assume at the recognition of the third word? What means did you employ to keep the first relation in mind while searching for a suitable term for the second relation? Which appeared first, the second relation or the second term of that relation? (If in doubt, repeat with six or eight trials.) What mental and bodily changes occurred with practice? Give evidence from your own experiences that the perception of a relation is accompanied by motor changes.

The individual student may express the average, range, and M.V. of his logical association time for Experiments 65 A to 65 E, using Table XXVII as a model. It is well to combine the results of all members of the class, using total average, of course.

The logical relations of supraordinate ("apple" — "fruit"), part-whole ("elbow" — "arm"), agent-action ("fire" — "burns"), and adjective-noun ("sharp" — "knife") may be used to extend the study of logical associations. Familiarity with the processes of logical associations, so-called, aids in the study of purposive thinking. List the major causes of the Civil War. Do likewise for the causes of the American Revolution. What does such a task show about the relation between familiarity and reasoning? Reaction time obtained for different logical associations should be compared with the norms given in the following table:

TABLE XXVII. AVERAGE OF INDIVIDUAL AVERAGES, AVERAGE DEVIATIONS, ETC.[1]

Nature of Logical Association	Average Time in Seconds per Single Response	Average Deviation of Individuals from General Average (Seconds)	Range of Individual Responses (Seconds)
Easy opposites	1.11	0.12	0.85–1.40
Easy verb-object	1.31	0.14	1.10–1.55
Supraordinate concept	1.54	0.31	0.90–2.50
Subordinate concept	1.84	0.31	1.20–2.63
Part-whole	1.53	0.27	1.03–2.50
Whole-part	1.57	0.32	1.13–2.35
Agent-action	1.30	0.12	0.93–1.70
Action-agent	1.55	0.32	1.03–2.68
Adjective-noun	1.53	0.28	1.08–3.05
Mixed relations	3.14	0.53	2.33–4.40

READINGS. **16**: 226–227, 233–234; **29**: 230–235, 347; **35**: 78–84; **37**: 56–67.

[1] Taken from Woodworth and Wells (**37** : 65).

EXPERIMENT 66. To study the Character of the Relations existing between the Key Word and the Response Word in Association Reactions (Two Students)

Material. Fifty key words; stop watch or Sanford chronoscope; ruled paper for records. (If the association time was determined in the preceding experiment, the results will suffice for this one.)

Procedure. E gives a "Ready" signal and then starts the watch just as he pronounces the key word, and stops the watch when S responds with an associated word. E adheres strictly to a uniform method of pronunciation. E records on the same line the key word, associated word, the association time, and saves a space for recording the nature of the association.

Results. Subject's report. Examine results and classify the responses as far as possible according to the plan given here. Should the headings prove inadequate, consult the literature with a view to revising the plan to serve your results more closely.

Class 1. Repetition. These sensorimotor responses of one sort and another usually arise from the imitative and suggestive tendencies resident in the visual and audile speech-motor arcs; for example, key word "stem," response "tree"; next key word "lamp," response, again "tree"; or key word "salt" and response "salt."

Class 2. Speech habit. The responses of this class are due (1) to the speech associations of everyday life (for example, "bread" — "butter"; "hammer" — "tongs") or (2) to sound, as "crack" — "whack."

Class 3. Contrast. For example, "swift" — "slow." Some apparent cases of contrast are due to speech habits, as "wise" — "foolish," "left" — "right."

Class 4. Synonym. For example, "sharp" — "keen," "bashful" — "modest."

Class 5. Coexistence. For example, "team" — "wagon," "soldier" — "gun."

Class 6. Supraordinate. For example, "owl" — "bird," "lily" — "flower."

Class 7. Subordinate. For example, "fruit" — "apple," "garment" — "coat."

Class 8. Object relation. For example, "orange" — "eat," "deer" — "shoot."

Class 9. Subject relation. For example, "boy" — "play," "horse" — "run."

Class 10. Simple predicate. For example, "iron" — "heavy," "spinach" — "green."

Class 11. Egocentric. For example, "afraid" — "not," "hate" — "nobody." These responses reflect some personal attitude.

Class 12. Casualty. For example, "tired" — "impatient," "poverty" — "sickness."

The following arrangement of the results will prove convenient for study:

Key Word	Association Word	Time	Nature of Association
drink	water	0.6 sec.	object relation
captain	ship	0.8 sec.	coexistence

Discussion of results. What classes of association show about the same reaction time? Note the classes giving the shortest and the longest time respectively. Is this an exception or is it generally true of the records of other subjects? Give classes of association formed in your thinking similar to those involved in this experiment. Which classes of associations resemble those made in thinking to solve a problem? What name might be given to associations bearing these relations?

Readings. **15**: 20–28; **35**: 78–84; **37**: 56–67; **38**: 300–310.

EXERCISES

1. Give some causes which in your experience have led to forgetting. Can you report from your own experience for or against the theory that we forget those things which are unpleasant to us? Who is the author of this theory?

2. Give one principle you have learned from experimental work that will lessen forgetting.

3. How may a principle of association be applied to the detection of validity of testimony in a criminal?

4. Describe your method of trying to recall a name.

5. How may emotional complexes be studied by the association method? What modern treatment makes use of this method in diagnosing mental disorders?

6. Give examples of controlled association in various arithmetical operations.

7. Give examples of three pairs of ideas, each connected by association, as man and wife; of three series of ideas, as a multiplication table; of a group, as a class.

8. One starts to another room to find a certain article. When the room is reached the article is forgotten. What causes the forgetting? Why will memory generally come if one goes back to the first position and starts again exactly as before?

9. What is the relation between retention and "cramming"?

10. Give examples from your own experience of the effect upon retention of the purpose or resolve to learn when studying.

11. Why may the sight of an orange make the mouth water?

12. How does the training of animals depend upon association? (Conditioned reflex.)

13. How may association account for our fears by the principle of conditioned reflex?

14. Give an example of the formation of a new habit and explain the part played by association.

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CHAPTER VII

PERCEPTION

1. Perception is the first operation of all our intellectual faculties and the inlet of all knowledge in our minds. — JOHN LOCKE, *An Essay concerning Human Understanding*, Vol. I, p. 262

2. Besides sensational elements, moreover, perception in all probability includes certain unemphasized relational elements.— MARY WHITON CALKINS, *An Introduction to Psychology*, p. 169

3. Perceptual activities constitute a type of psychological action in and through which are developed the significance of meanings of things and relations operating in the adaptation of the individual to his surroundings and in the control of them. — J. R. KANTOR, *Principles of Psychology*, p. 250

4. We have found certain laws of configural function developing on the one hand through mere maturation — though not to be sure without stimulation — and on the other hand being recast or newly created. . . . In the adult a configural function is, in its phenomenal aspect, a *perceptual* experience in its own right; for it is neither a mere judgment, nor a mere apprehension of sensations. The development of these configurations cannot be conceived as a simple combination of sensations, or as the outward manifestation of a juxtaposition of repeated sensations. — KURT KOFFKA, *The Growth of the Mind*, p. 297

TOPICAL OUTLINE

Nature of Perception

- *A*. Acquired concrete mental responses
  - I. Primary differentiated reaction systems of meaning
    - 1. Meaning of an object aroused by combining the reaction systems developed by it
    - 2. The core: "perceptual-reaction-system" performing an interpretative function to present and new sensations
  - II. Component factors
    - 1. Present sensations (peripherally aroused)
    - 2. Central sensations (aroused by perceptual patterns)
  - III. Laws governing the coöperation between present and central sensations
    - 1. Laws of attention
    - 2. Laws of association
- *B*. Relation of perception to other forms of response
  - I. Attitudes
  - II. Images
  - III. Motor reaction

Kinds of Perception Classified

- *A*. According to degree of development
  - I. Primary perception
  - II. Mixed or secondary perception
  - III. Symbolic perception
- *B*. According to the general aspects of the perceived object
  - I. Qualitative perception: red, hard, bitter, c^1–c^2 (octave higher)
  - II. Spatial perception
    - 1. Development in the individual
    - 2. Kind classified by receptors
      - *a*. Tactual
      - *b*. Visual
      - *c*. Auditory
      - *d*. Kinæsthetic
  - III. Temporal perception (an abstract of intervals between sequential events)
    - 1. Probable origin of primary temporal intervals
      - *a*. Connected with the rhythmical changes of the neural processes in the brain
      - *b*. Connected with the rhythmical changes occurring in the vital organs
      - *c*. Connected with the intervals afforded by the accented measures: in walking, in arm-swinging
    - 2. Estimation of passing time and of time in retrospect
- *C*. According to the degree of fidelity between the perception and its object
  - I. True perceptions
  - II. False perceptions
    - 1. Illusions
    - 2. Hallucinations
  - III. General causes of illusions
    - 1. Sensation associated with the wrong perceptual pattern
    - 2. The sensation impulse controlled by habitual modes of response
    - 3. Influence of external conditions

Purpose of Perception

- *A*. To focalize and control motor responses
- *B*. To provide the concrete elements of knowledge

INTRODUCTION

The problems of perception are found in the statements that sensations in their functional relations form the elements of knowledge and that they begin to function as knowledge just as soon as they become interrelated into a system corresponding to the permanent arrangement of the properties of objects. The fact of interrelation is described as sensation fusions, as

blends and patterns, as "figured consciousness," which, by repetition, come to form the permanent part of our perceptual reaction system. Common or familiar objects are usually perceived in permanent ways, although the sensations aroused by them may never be quite the same on any subsequent occasions. The corners of buildings, of rooms, of paving stones, of tables and desks, are perceived as square despite the fact that the sense imagery of their right angles is either obtuse or acute. Likewise the size and shape of known objects are perceived as unaltered, whether far or near, whereas the sensations aroused by them change with the change of distance. The same principle operates in language. One need not and usually does not hear all the words of a conversation or of a public speaker. If enough is heard to arouse meaning, the permanent factor, the wrongly heard and unheard portions are ignored or unnoticed. Such observations tend to show that sensation patterns formed and stabilized under the stress of environmental adjustment perform the leading function in perceptual experience; that the perception of an object is a resultant of two factors, present sensation and centrally aroused experience relative to the object; that the perceptual reaction systems constitute the norms or standards, as it were, by which sensations are interpreted; that one and the same object connects with several possible reaction systems; and that the one which it arouses depends upon expectancy, "mind set," and upon the laws of association. The experimental problems of perception grow out of the relations that exist between the central reaction systems and the present excited sensation. Meaning, hallucination, all false perceptions, and illusions depend upon the sort of joint action that occurs between these two general factors.

We must remember, however, that perception is a total reaction, a unique mental operation in its own right and not a fusion of separate sensations and ideas.

Perhaps the most striking example of the "wholeness" in perceiving is furnished by visual perception, where each eye contributes a somewhat different impression of one and the same object which is perceived as one.

GENERAL ASPECTS OF PERCEPTION

EXPERIMENT 67. To study the Nature of Perception (One Student)

Material. A coin (penny, five-cent piece, quarter, or fifty-cent piece), stamp, state seal, or some familiar small object; pencil and paper.

Procedure. S draws the object from memory, filling in details from memory only, being careful not to make use of imagination. On the same sheet he lists the details of the drawing. S then takes the object and makes a drawing from direct observation, filling in details as carefully as possible and making a list similar to that above.

Results. *Subject's report.* The drawings and lists are the subject's report.

Discussion of results. Compare the two drawings and lists of words as to definiteness, detail, and stability. How does your perception of a table differ from what you really see according to the laws of perspective? Give other examples of this principle.

READINGS. **2**: 122–129; **26**: 95–97; **30**: 423–433.

EXPERIMENT 68. To study the Component Factors of a Perception

A. A Study with a Word having Incomplete Contours (*Class Experiment*).

Material. Large card containing a word as shown in Fig. 19.

Procedure. The instructor places the large card, which should not have been seen before by the subjects, at a convenient distance before them. They print the word as it appears. The card is passed around and studied at close range.

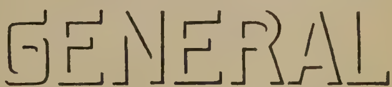

FIG. 19. Letters with incomplete contours

Results. *Subject's report.* Describe the letters on the card as seen from a distance and as seen ten inches away.

Discussion of results. Explain why the incomplete letters were perceived as complete. What were the peripheral sensations in the perception? What formed the basis of the centrally excited sensations?

B. A Study with a Puzzle Picture (*One Student*).

Material. Two puzzle pictures; watch or clock.

Procedure. S notes the time and begins to study the puzzle picture, which he should not have seen previously, until he has worked out the hidden form. He records the time, and then takes

up the second picture and works out the hidden form. After at least ten minutes from the time he solved the first puzzle, if he has finished the second, he tries the first again and notes the time before the hidden objects come to view. The same is done with the second puzzle. This experiment might be repeated after twenty-four hours.

Results. *Subject's report.* Give time results for the two pictures.

Discussion of results. How did definiteness and form of hidden objects compare in the two trials? What set of sensations was aroused by the picture at the second exposure that was not present at the beginning? What is meant by "perceptual fusion"? Give Titchener's four points in the psychology of perception. Give examples from everyday life of three perceptions and note both central and peripheral factors. What are the component factors of a perception?

Inference. ------------------------------------

READINGS. 4: 238–244; 8: 312–317; 9: 279–282; 10: 134–137; **18**: 170–176; **27**: 371–372.

EXPERIMENT 69. **To study Perception as a Result of the Interpretation of Present Sensations by Earlier Experience (Class Experiment)**

Material. Large tachistoscope; five lists of ten words, and each word printed on a card cut to fit the tachistoscope.

The words of the first list are misspelled by substituting a wrong letter; in the second list a letter is omitted from each word; in the third list two letters exchange places; the words of the fourth list lack a letter and a wrong letter is substituted for another letter; and the fifth list is composed of psuedo words, formed by arranging letters so as to appear like words. Sample lists are here given.

LIST I	LIST II	LIST III	LIST IV	LIST V
Christnas	phenomna	postertiy	adnertse	sqrum
abstruce	mechaical	aboslute	baibaran	clryx
agensy	succesful	eductaion	bivoclar	wolurs
uniteb	mirculous	poeple	cantolope	ranbdor
molicule	neutrlity	daigram	complomnt	dlear
ganeral	pculiar	expeirment	condemplte	thogk
exidus	elvation	wheraes	curolary	olgyr
antecipate	mnority	varaible	denudate	klodge
gridirun	resurection	qusetions	divurgnce	mantyr
appedite	mjority	stiarcase	domecle	boply
swallaw	obsrvation	psyhcology	ecanomc	tpxoy
pishing	muscian	scaricty	exectrve	feyton

List I	List II	List III	List IV	List V
clemax	indepndent	bevreage	exturpte	meytlo
simelar	capbility	disicple	finavcir	toxpy
oadmeal	supension	receration	defaciet	luyt
foreiqner	mesles	specail	hasitat	mrasont
menory	retalate	expereince	ilusdrate	varmup
offecial	medlesome	expdeition	inrald	vaswint
hunding	conscius	sentmient	logerthm	oxvoses
depravety	deficent	staedily	chanpagn	blukade

Procedure. S must not know the nature of the words or their error. The instructor tells S that a series of words is to be exposed and that they must be written as soon as perceived. He gives the signal "Ready" at each exposure just before dropping the screen of the tachistoscope. Ample time to perceive the word is allowed S after the exposure. He should tell or write how he makes the word.

Results. The results may be arranged in the following form:

TABLE XXVIII. EFFECT OF CENTRAL SENSATIONS ON PERCEPTION (MISSPELLED WORDS)

Nature of Response	Nature of Misspelling				
	Wrong Letter Substituted	One Letter Omitted	Two Letters Inter-changed	One Letter Omitted, One Wrong	Pseudo Words
Words perceived as exposed . .					
Words perceived as correct . . .					

S now compares his results with the words in the original lists and makes the computations necessary to construct the table. "Words perceived as exposed" means that the error was detected and so recorded. "Words perceived as correct" means that the error was not detected and that the word was written in its correct form.

Discussion of results. In which list was the smallest number of errors detected? Account for the failure to detect errors. How does your explanation account for the proofreader's illusion? Which type of error in the first three lists is most likely to be overlooked? Account for the relatively small number of words perceived in the fifth list. What distinction may be made between *seeing* a word and *perceiving* a word? Indicate some of the relations that exist between outside

and inside sensations as they are involved in perception of misspelled words. Which list shows the highest number of detected errors, and why?

Inference. --

READINGS. 2: 127; 4: 238–244; 8: 326–329; 18: 170–176; 27: 364–367.

EXPERIMENT 70. **To study the Effect of Preperception on the Threshold of Perception (Coöperative Experiment)** [1]

Material. Measuring tape; two sets of five cards each 7 in. by 3 in., on which are drawn familiar symbols, one on each card, in various positions (for example, one card may have a symbol near the upper edge, another card may have one near the lower edge, another card one in the center, etc.) so that the location of one will not lead to the location of another. The symbols should be drawn distinctly in india ink, but with a fine pen, and should not measure more than $\frac{3}{8}$ in.

Procedure. 1. *Without preperception.* The instructor appoints from the class (1) subjects; (2) an experimenter, whose duty it is to measure distances from S's instep to a point directly under the suspended paper; (3) a recorder, who records the result on the board, and (4) a monitor, who keeps the slips in order and watches to see when S correctly perceives a symbol. The remainder of the class copy the table as it is filled in, the process being repeated with four subjects. The slip is fastened at some convenient point where the light will be on it and at such an elevation that it can easily be seen. S is to observe the symbol from various distances. Starting at a point at which nothing is visible on the card, he approaches it slowly, watching attentively for the symbol. As soon as S senses something he stops, and E measures the distance from his instep to the point directly under the suspended card. This first distance is recorded as the partial perception distance. S then slowly advances until he thinks he knows what the symbol is, and whispers his perception to the monitor. If this is correct, the distance is measured and recorded; if not, he goes closer until he correctly perceives the symbol. The second distance is noted as perception distance and gives the threshold for that symbol. The same procedure is carried out with the four remaining cards in the first set.

2. *With preperception.* The procedure is as above, except that S is each time shown the symbol before starting toward it. Use the cards of the second set.

Results. The results may be arranged in the following form:

[1] Modified from Witmer's *Analytical Psychology.*

TABLE XXIX. EFFECTS OF PREPERCEPTION ON PERCEPTION

SUBJECT	FIRST DISTANCE — PARTIAL PERCEPTION						SECOND DISTANCE — COMPLETE PERCEPTION					
	Symbol					Average Threshold	Symbol					Average Threshold
	1	2	3	4	5		1	2	3	4	5	
I. WITHOUT PREPERCEPTION												
A												
B												
C												
D												
Average .												
II. WITH PREPERCEPTION												
A												
B												
C												
D												
Average .												

Discussion of results. What has caused the lowering of the threshold in procedure 2? Explain why. Discuss individual differences and correspondence of results. Give three practical applications of this principle to daily life. Discuss the application in education.

Inference. State the principle as inference.

READINGS. 29: 25–27.

EXPERIMENT 71. To observe Changes in Perception shown by Reversible Figures (Two Students)

A. With Ambiguous Object.

Material. The duck-rabbit head. This well-known figure may be enlarged and used for a class exercise, but the experiment below is given for two students, using the figure on page 168.

Procedure. S glances at the figure and calls out at once what he perceives. Now he fixates the figure and tries to keep his gaze steadily on it for one minute, while E keeps time and notes the number of reversals as S calls them. S repeats the procedure while E notes any eye movements. S fixates for the same time first the right and then the left of the figure, calling out his perceptions and any changes. E watches for eye movements, using a mirror if necessary.

Results. *Subject's report.* Give an account of the perceptual pattern as you fixate different parts; also of control of eye movement.

Experimenter's report. Make a record of S's report with times and changes and eye movements.

Discussion of results. Which is perceived at a glance, duck or rabbit? What reaction pattern responds to the impressions on the right? on the left? Why is this? If there are changes in perception

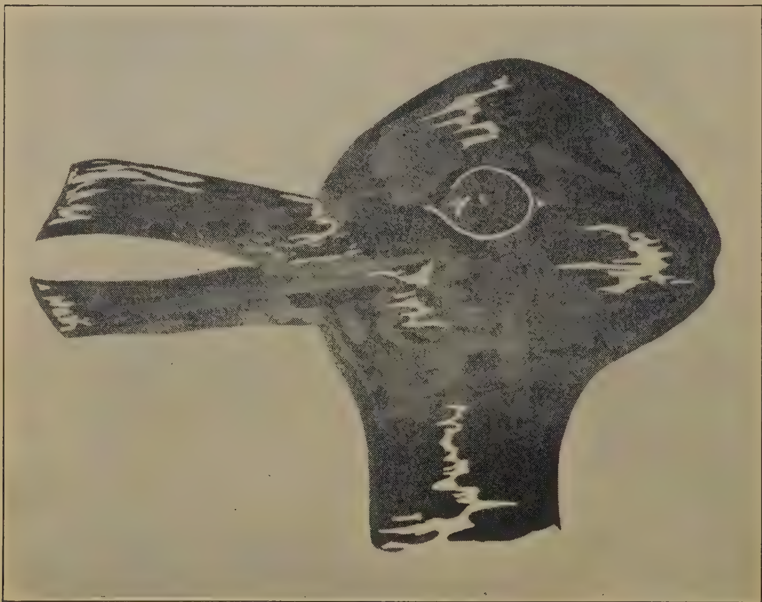

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FIG. 20. Ambiguous object

when S looks at the middle point, which perception remains the longer? Why are there changes? Are any changes of eye movement observed? How does this experiment illustrate the laws derived from Experiments 69 and 70?

B. With Geometric Figures.

Material. Simpler reversible figures, the stairway and pile of blocks.

Procedure. 1. *Study of Fig. 21A. Pile of blocks.* S examines the pile of blocks, fixating some particular point (say, the middle of the figure) for one minute, and then tells E the number of blocks he sees. As the number changes he calls the number of blocks then

visible, continuing for two minutes. He may fixate also the lower corner of the uppermost square. After E has made a record of the time and the number of blocks, the procedure is repeated for about the same time while E watches for eye movements.

2. *Study of Fig. 21B. Ambiguous figure.* S examines the figure as in the study of Fig. 21A, E making similar records and observations.

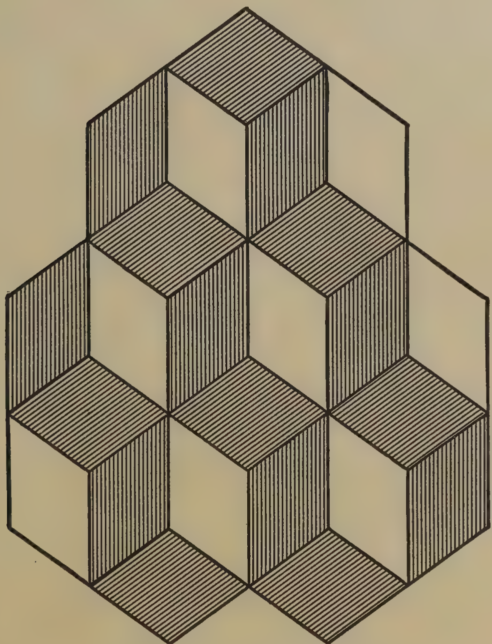

FIG. 21 A. Pile of blocks

Results. *Fig. 21A.* How many blocks were visible at first? How many after the change? What special fixated point gave six blocks? What one gave seven? Which perception lasted longer? Why?

Fig. 21B. Which of the two perceptions is seen first, and which is more permanent? Why?

Discussion of Fig. 21A. What facts tend to indicate the cause of the change? Does E's record of eye movements check with the reported changes?

Discussion of Fig. 21B. Were you able to hold this figure as an overhanging wall by trying to do so? At what points do you have to fixate it to produce this result?

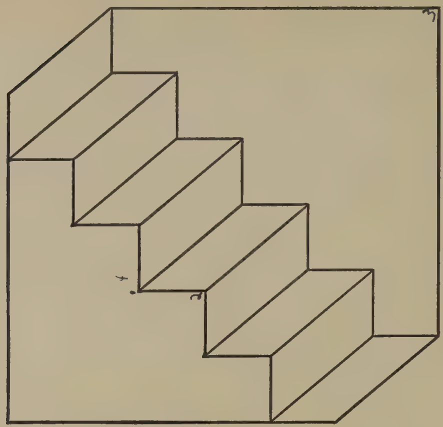

FIG. 21 B. Ambiguous figure

What part is played in these changes (in the case of both figures and of duck-rabbit) by attention (see eye movements, point of fixation) to peripheral sensations? by the perceptual pattern due to experience? What do these experiments show as to the stability of our perceptions? as to unity? Give an example from your own experience of an unstable perception.

READINGS. **9**: 282–295; **18**: 174–176; **25**: 153–157; **30**: 423–424, 431–433.

PERCEPTION OF SPACE

EXPERIMENT 72. To study Tactual Space. Localization of Touch (Two Students)

Material. Drawing paper; pen; india ink; compasses; millimeter scale; two pins.

Procedure. S, with eyes closed, seats himself comfortably at the table and places his left forearm, volar side up, on the table. E marks off on the forearm with ink a rectangle 50 mm. by 75 mm. and a similar one on drawing paper. E touches S with the pinhead somewhere within the rectangle, pressing gently but firmly enough to indent the surface. S tries immediately to touch the same point with another pin, making a deliberate and direct movement and not feeling about for the point. This point is noted by E, who places both points on the drawing-paper rectangle, getting by means of compasses the exact positions and connecting the two points by a light line. The

distance is measured in millimeters, the direction of the error being noted, whether proximal or distal. Similar trials are made, using the volar surface of the wrist and the palmar surface of the hand. Ten trials or more are made in each of the three cases.

Results. Subject's report. Give an introspective account of what apparently constitutes the "local sign."

Experimenter's report. This consists of drawings as described above (see Fig. 22).

Fig. 22 shows a convenient form of record. In the center of the dotted line is recorded its length in millimeters; the dot at one end, representing E's touch, is labeled *E* with a numeral before it indicating the number of the trial. The dot at the other end, representing S's touch, is labeled *S*, and is prefixed by the same numeral. In this way the record can be made from the diagram, and tables may be constructed. In these tables (one for each of the three cases) the first column should contain the figure indicating the number of the trial, the second column should contain the error in millimeters, and the third column the direction of the error. The averages of the error columns give a relative estimate of the accuracy of localization for the three surfaces tested.

Discussion of results. How do you know that you have touched the right spot? What kind of imagery did you use in locating the point? What was the effect of practice? of fatigue? Can you explain your results as to relative accuracy of surfaces touched? Is any law evident in the direction of your error? Discuss this point. What have you observed as to the accuracy of touch localization in young children? How do you know your right hand? Give two "local-sign" theories. Give a historical account of the "local-sign" concept. How can the tactual percepts of the blind be explained?

Inference. State the laws of touch localization.

READINGS. **1**: 171–174; **20**: 938–940; **21**: 74–81; **25**: 184–186; **29**: 110–113.

EXPERIMENT 73. To study Localization of Sound (Group Experiment)

A. Laboratory Exercise.

Material. Yardstick or meter stick; five berry-cappers; bandage for blindfolding; watch; table form.

Procedure. 1. *Preliminary test.* It is necessary first to find if the sensitiveness of both ears is practically the same. Bring a rather loud-ticking watch from a distance so great that it cannot be heard slowly up to each ear, holding it on a level with the ear and directly

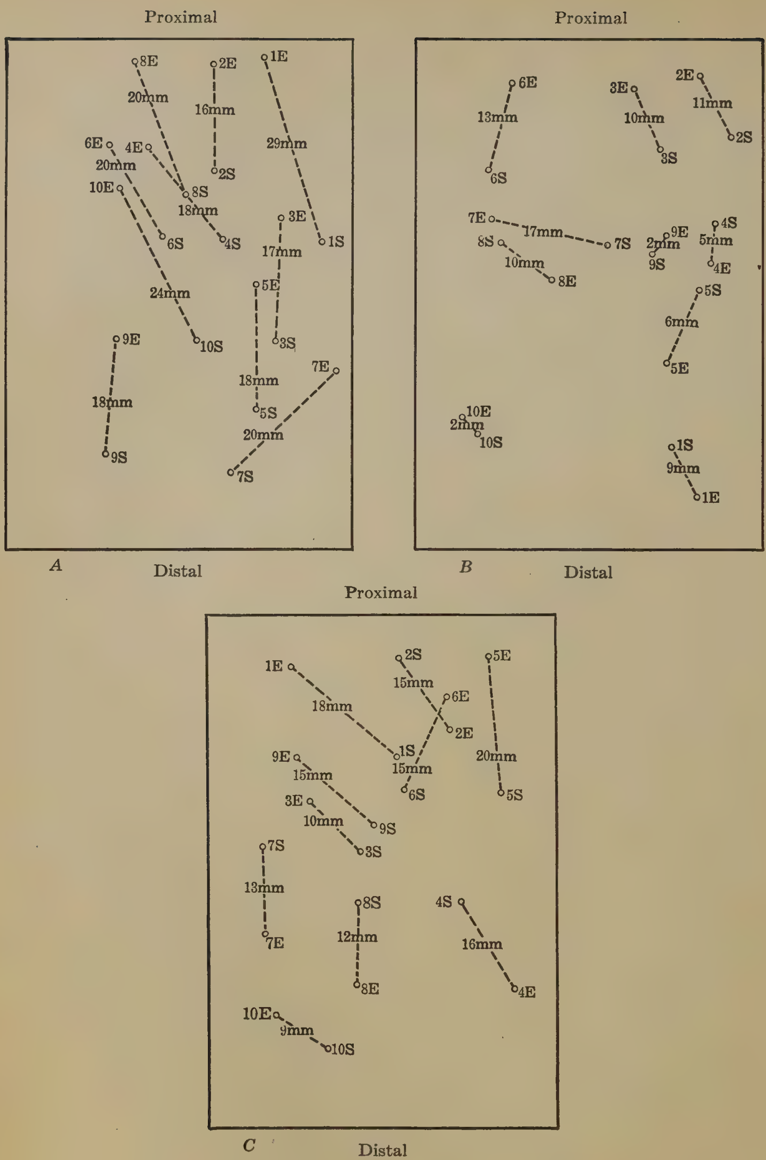

FIG. 22. Localization of touches

A, volar surface of forearm; average error, 20 mm. *B*, palmar surface of hand; average error, 8.9 mm. *C*, volar surface of wrist; average error, 14.3 mm.

left or right as the case may be. When S hears it he calls "Stop," and the distance from the ear is measured. Then with the watch a few inches from the ear, it is moved away until the sound is just inaudible to S. The average of the just noticeable distance and the just unnoticeable distance is found for each ear. If the distances are about equal, S may qualify for the experiment; otherwise further search must be made until a subject whose ears are equally sensitive is found.

Since it is very essential that this experiment be carried on in a quiet room with no distractions or sound interferences, if the class is large several groups may be formed to work in different rooms. Ten or twelve may work together. Besides S there are needed for the experiment five persons to give the stimulus, designated experimenters; a person to give signals to these experimenters; and several to take records of S's responses. All of these must be at attention, watching signals and noting S's responses, while absolute quiet prevails. The signaler has a written plan for the fifty trials given him by the instructor. He checks each trial as it is made.

2. *Procedure proper.* S should be seated as near the center of the room as possible and uniformly in the same position during the experiment. The five experimenters, each provided with a berry-capper, should be stationed so that they can give the stimulus at one meter (or yard) from the right and the left ear of S, and the same distance to the front, to the back, and above the center of the head. The experimenters also should be seated, and the hands holding the berry-cappers should be kept in a uniform position when giving the stimulus.

S, who is blindfolded, and the five experimenters take their respective positions. The signaler calls "Attention," then signals to one of the experimenters, who clicks his berry-capper. S calls "Front," "Back," or whatever he judges the direction to be. The recorders enter "1" in the proper column. The only words spoken should be "Attention" from the signaler and S's responses as he gives them. This process is continued for the fifty trials, there being ten trials in each of the five directions. The results are recorded in a blank form. To find the percentage of correct judgments (which should be placed below the totals in each column), divide the number correct by 10. Since expectation is a disturbing factor of sound localization, it is well for the signaler, after S has designated the direction, to request S to state if the judgment given on the direction coincided or not with his expectation.

Results. The results may be arranged in the following form:

TABLE XXX. EFFECT OF DIRECTION IN LOCALIZATION OF SOUND (RESPONSES OF JUDGMENT)

Trial	Above		Front		Back		Right		Left	
	Correct	Wrong	Correct	Wrong	Correct	Wrong	Correct	Wrong	Correct	Wrong
1 . . .										
2 . . .										
. . . .										
. . . .										
. . . .										
10 . . .										
Total per cent correct										

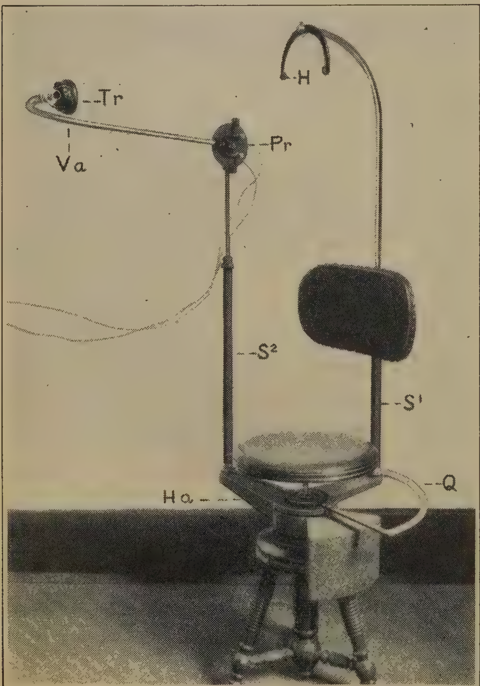

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FIG. 23. Sound cage

Discussion of results. Which direction shows most errors in location? Which shows fewest errors? Explain this. What factors other than hearing enter into the localization of sound? In this experiment we definitely make use only of the sound-localizing reflex. Ordinarily we use other reflexes; that is, we turn the head or the body or adjust ourselves to other positions. When does one use only the sound-localizing reflex? Give examples of sound localization, showing difficulties in daily life, and suggest methods by which these difficulties may be overcome.

B. Classroom Exercise.

The difficulty of securing proper conditions for experimenting on sound, particularly on its localization, in the usual laboratory with large classes may often make it desirable to give a rough demonstration in a lecture room. For this purpose the sound cage is the most satisfactory instrument (an instrument of precision when used in a sound-proof room).

	Stimulus Points									Total
	R	RB	RF	B	Above	F	LF	LB	L	Errors
R										
RB										
RF										
B										
Above										
F										
LF										
LB										
L										

Grand Total ____

FIG. 24. Form for recording judgment in locating sounds

Material. Sound cage with telephone receiver; two small batteries and key; blank forms for recording S's responses.

The adjustable parts of the cage are mounted on a heavy tripod. The essential parts of the cage are (1) a heavy horizontal arm *Ha* that rotates on ball bearings about a vertical axis passing through the center of the seat, the amount of rotation being measured by a protractor *Q*; (2) two heavy standards S^1 and S^2; to S^1 is attached a back support and head grip *H*; on S^2 is mounted a steel tube or arm *Va* bent to a quadrant which carries a telephone receiver *Tr* and wires. The tube rotates about a horizontal axis, passing through the upper end of S^2. The protractor *Pr* shows the angle made by the arm with a horizontal plane passing through S's ears. By means of the two arms *Ha* and *Va* the receiver can be placed at any point in a hemisphere whose radii center at the mid-point of the imaginary-line joining S's ears.

Blank forms for members of the class may be arranged according to the sample here given.

Procedure. S is blindfolded and back and head are properly fitted to the supports of the cage. Explain to S that he will hear telephone clicks from nine and only nine different points: right, right back, right front, back, above, front, left front, left back, left. Familiarize S with the names of these points by a short drill. E always gives signal "Ready" before pressing electric key, and S makes a verbal response by using one of the terms above. Make ten trials for each point but in irregular order. Each member of the class enters the

response by a check mark in the column corresponding to the response and in the row opposite the symbol of the point at which the stimulus was given. Because of the fact that fatigue is likely to occur before ninety judgments are made, it is best to change subjects at the forty-fifth trial and complete the second half for the first subject at a subsequent period. Separate records must be kept for each of the subjects.

Results. Each member of the class summarizes the results from the blanks filled out during the experiment according to the following form:[1]

Rights (*R*, *RB*, *RF*) judged *Lefts* (*L*, *LF*, *LB*)	—— times	Total ——
Lefts (*L*, *LF*, *LB*) judged *Rights* (*R*, *RB*, *RF*)	—— times	
Fronts (*F*, *RF*, *LF*) judged *Backs* (*B*, *RB*, *LB*) or *Above*	—— times	Total ——
Backs (*B*, *RB*, *LB*) judged *Fronts* (*F*, *RF*, *LF*) or *Above*	—— times	
Above judged *Fronts* (*F*, *RF*, *LF*) or *Backs* (*B*, *RB*, *LB*)	—— times	Total ——
Above judged *Rights* (*R*, *RB*, *RF*) or *Lefts* (*L*, *LB*, *LF*)	—— times	
Above judged correctly	—— times	

Discussion of results. List the points in ascending order of accuracy of location, as indicated by the summarized results. Do the results show the relation between the difference in intensity of the sound stimulus for each ear and accuracy of localization? Have you observed inaccuracies in localizing sound in daily life? Do animals show confusion in localizing sounds? Devise an experiment to show the effect of practice on the accuracy of localization.

READINGS. **1**: 176–178; **4**: 118–119; **13**: 82–83; **15**: 180–181.

EXPERIMENT 74. To study Visual Perception of Three-Dimensional Space

A. The Outward Projection of Visual Images.

1. The Image formed by a Double Convex Lens (One Student).

Material. Double convex lens; candle; screen.

Procedure. S places on the table a lighted candle. He holds the lens near it in such a manner that a clear image of the candle is cast on the screen, which may be a sheet of cardboard or a wall or a blackboard. The image may be best observed, of course, in a darkened room. He varies the distance of the lens from the candle and notes the varying size of the resulting image.

[1] Modified from Max F. Meyer's *Manual of Psychology Demonstrations.* By permission.

2. The Projection of a Retinal Shadow (One Student).

Material. A black card about 7 cm. square; a pin.

Procedure. S holds a card, in the center of which he has pricked a pinhole, before the eye at a distance of about 6 or 8 cm., and between the eye and the card, almost touching the eye, he holds a pin, head up. He looks through the pinhole at the sky or a light and notes what he sees, observing any variation produced by moving the card to and from the face. He then pricks several pinholes and notes results.

Results. Subject's report. Describe the visible results of parts 1 and 2, and make drawings.

Discussion of results. Since the main refracting medium of the eye is the crystalline lens, comparable to the lens used in part 1, would the actual image produced on the eye screen (the retina) be erect or inverted?

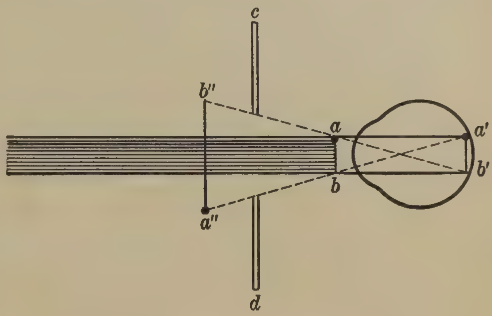

FIG. 25. The projection of the visual image of a retinal shadow

cd, card; *ab*, pin; *a'b'*, retinal shadow pin; *a''b''* projected shadow

In the pin experiment, since the pin is too near the eye to form an image it simply cuts off the light from the pinhole and a shadow is cast on the eye screen (the retina). A shadow is always erect; why, then, do we see the pin shadow inverted through the pinhole? Is the inversion physical or psychological? Where does the shadow pin appear? What are some of the psychological factors which enter into our judgment of the size, position, and distance of objects? What physical property of the retinal image aids us in estimating distance of objects?

Inference. What inference may we make from this experiment as to how retinal impressions are projected?

Draw a diagram similar to that in Fig. 25, and explain it.

B. Binocular Vision.

1. The Same Object has a Slightly Different Appearance to Each Eye, viewing it Separately (Two Students).

Material. Heavy white paper; paste; compasses; scissors; pen and ink; wire about 6 in. long; support.

With a radius of $2\frac{3}{4}$ in. describe a semicircle on the heavy white paper. From the same center with a radius of about $1\frac{1}{4}$ in. describe another semicircle within the first. Cut out the inner semicircle. Paste the straight edges of this sector together, lapping about $\frac{3}{8}$ in., forming a truncated cone.

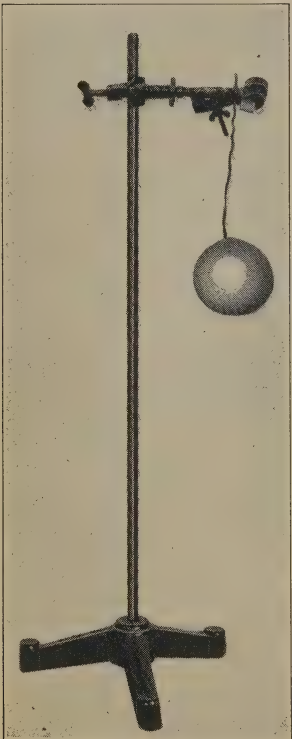

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FIG. 26. Paper cone

Procedure. S holds up his forefinger in the median plane, on a level with the eyes and about 25 cm. to the front. He closes the right eye and with the left eye observes the apparent position of the finger with reference to some chosen point in the foreground. He repeats this procedure with the left eye closed.

By means of a wire passed through the cone and fastened to a support as in Fig. 26, E adjusts the cone in front of S (who should be seated with his head in a headrest) on a level with the eyes, about 1 m. from the face and 2 m. or more from a blackboard or wall to the rear of the cone, the axis lying halfway between the lines of sight of the two eyes, and the smaller circle toward the eyes. S closes the right eye and looks at the cone with the left eye, using the screen or blackboard as a background, and E assists in the location. S observes the cone in this way with great care, making a pencil sketch on paper in outline. In like manner he sketches the cone in outline as it appears to the right eye. E measures on the screen the difference in position of the two images as seen by the right and the left eye.

Results. Subject's report. Describe objects seen in all cases as to position, appearance, etc. Make sketches.

Discussion of results. What is the difference in position of the finger seen with each eye separately? How do the sketches of the cone differ from one another and from the cone as seen with both eyes as to suggestion of relief or flatness? Which end of the cone here requires greater convergence? Compare positions on the screen of the right and left eye images?

2. The Binocular Visual Field and Corresponding Retinal Points (Two Students).

Material. Blackboard upon which is marked off a square meter divided into decimeter squares; crayon.

Procedure. S sits with his head in a headrest, so that his eyes are on a level with the central point of the meter square and about 1 m. distant from it. He closes the left eye and fixates the central point with the right eye. E explores with a crayon and marks out, at S's direction, an area of distinct single vision for the right eye. S, holding the same position, now fixates the screen with the right eye closed, and E marks off in like manner an area of distinct vision for the left eye.

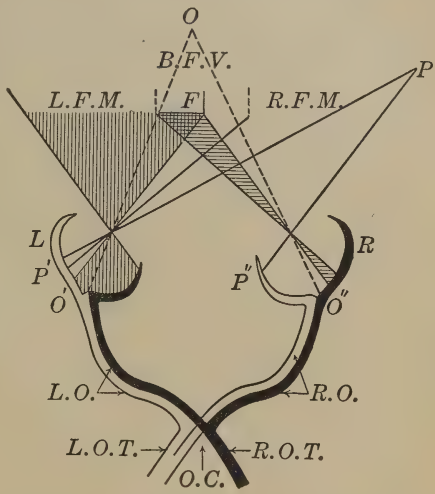

FIG. 27. Corresponding foveal areas, homonomous halves of the two retinas and the binocular field of vision

R, right eye; *L*, left eye; *R.O.*, right optic nerve; *L.O.*, left optic nerve; *R.O.T.*, right optic tract; *L.O.T.*, left optic tract; *B.F.V.*, binocular field of vision; *R.F.M.*, right field of monocular vision; *L.F.M.*, left field of monocular vision

Results. Subject's report. S carefully copies this drawing to scale on cross-section paper. Drawings should be duly described.

It will be seen that there is a portion of the two visual fields thus mapped out that is common to the two eyes. This is the binocular visual field, and the rays of light from all points of this field fall upon corresponding points of the fovea and the surrounding region in each eye.

In the accompanying diagram (Fig. 27) the two eyes are represented as fixated on the point *F*. *O* is a point in the binocular visual field and *P* a point without. It will be seen that an image of the point *F* falls, of course, upon the fovea and an image of the point *O* falls a corresponding distance to the right of the fovea in each eye, as in points O' and O'', but the images of the point *P* fall at P' and P'' at unequal distances from the foveas. These are called disparate points, and the projected images do not coincide, whereas images

from corresponding points within the binocular field are projected to the same point and a single perception results.

3. Fixation of the Eyes upon a Point causes Double Images of Other Points (One Student).

Material. Pen; pencil.

Procedure. (1) *When the fixation point is nearer than the object.* S holds up before his eyes in the median plane the pen and pencil, the pen at a distance of about 12 cm. and the pencil at arm's length. He fixates the pen and continues to gaze at it fixedly until he can see two pencils as well as the pen. By closing alternately the right and the left eye (always being careful to keep the fixation point) he discovers to which eye each of the two images of the distant pencil belongs.

(2) *When the fixation point is farther away than the object.* S holds up the pen and pencil as before, but now fixates the distant pencil and gazes intently until he perceives in addition two images of the pen. By closing the eyes alternately he discovers to which eye each image belongs.

Results. *Subject's report.* Describe the two images in each case — position, general appearance, clearness — and state the position of the right and left images in each case with respect to the right and the left eye.

In Fig. 28, *a*, *F* is the fixation point and *O* the object, while the points *O*, *O′* and *F*, *F′* represent the points of the retinas upon which the rays of light from *O* and *F*, respectively, fall.

In Fig. 28, *a*, the eyes are fixated on the near point. The involuntary muscles control the refracting media so that a distinct image of the point *F* is formed at the fovea of each eye, *F* and *F′*; according to habit it is projected to *F* and we see one distinct image of the point coinciding with the point itself. This reaction of oneness arises from the habitual use of these areas of the retina for the observation of one and the same point alone, as distinguished from all others in the visual field. The rays of light from *O*, represented by dotted lines, strike the two retinas, respectively, at *O* and *O′*. These points, being on opposite sides of the retina, are not corresponding points (see page 179), and hence the two images formed on the retinas and projected out along the ray lines do not coincide. Instead we have the two images in the region of *F*, and *X* and *Y* are uncrossed.

In Fig. 28, *b*, in like manner, *O* and *O′*, being in the left halves of the retina respectively, are disparate points. In this case (the images being projected as usual along the ray lines until the region of the plane of the fixation point is reached) the rays cross before they are

located. Therefore we have the image formed by the right eye on the left and that formed by the left eye on the right.

Discussion of results. Why are objects seen double? What points give double images? If double images are constantly formed, why do we neglect them?

4. Fusion of Images (One Student).

READINGS. **8:** 33–37, 110–112; **18:** 312; **29:** 132–136.

Material. Paper tube 25 cm. long and 2 cm. in diameter; black card with two circular holes, $1\frac{1}{2}$ cm. in diameter, the interocular distance apart; small mirror; meter stick; mounted diagrams of cone images placed the interocular distance apart (see Fig. 29 for interocular distance); stereoscope.

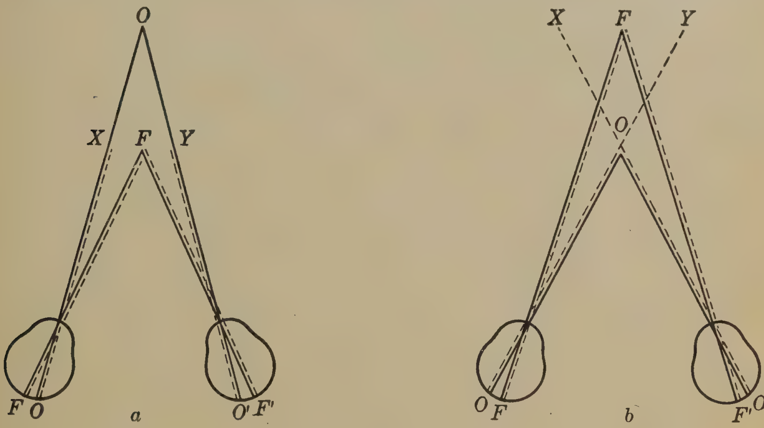

FIG. 28. The doubling of objects

a, the homonomous doubling of objects farther than the point of fixation; *b,* the heteronomous doubling of objects nearer than the point of fixation

a. Effect of greater intensity of one image.

Procedure. S holds the paper tube in front of the left eye and looks through it toward some distant point. He holds the palm of the right hand facing the right eye and touching the tube midway of its length. The right eye looks at the hand while the left eye looks through the tube. S looks straight ahead with both eyes, then with the right eye alone, and then with the left eye alone.

Results. *Subject's report.* Record what is seen.

Discussion of results. Which is the dominant image? Why? Why does the peculiar illusion occur?

b. Approximate determination of interocular distance between lines of monocular sight.

Procedure. S holds up his two forefingers, separated by a distance of about 12 cm., directly in front of the eyes and about 25 cm. from them. He looks fixedly between the fingers at a distant point on the wall or sky until he can see two images of each finger, varying the distance if necessary. S now brings the fingers nearer together, still keeping the distant fixation point, until they seem to combine into one.

Results. *Subject's report.* Give observations and descriptions of the double images, with special note of what happens as the two fingers approach each other. Measure the distance at which images fuse. It is the interocular distance.

Discussion of results. Why did the two images combine? Which two combined? What was the character of the resulting image with respect to clearness, relief, or flatness as compared with the two which combined to make it?

c. Fusion of like images at interocular distance.

Procedure. S holds the black card close in front of the face and looks through the holes at some distant object. He moves the card out a little and varies the distance until a distinct change is seen.

Results. *Subject's report.* State what is seen when the lines of monocular sight shift and combine.

Discussion of results. Why did the two holes fuse? Compare this result with part *a*.

d. Fusion of eyes into cyclopean eye.

Procedure. S holds the hand mirror in front of the eyes, with each eye as in distant fixation, staring straight ahead. He brings the mirror up close until the image changes.

Results. *Subject's report.* Give a description of the fusion of the two images.

Discussion of results. What causes the fusion?

e. Binocular fusion of images slightly unlike.

Procedure. S takes the card containing two diagrams (separated by the interocular distance) of the cone as seen with each eye separately, the right-eye image being drawn on the left and the left-eye image on the right, and holds it at the usual reading distance. (1) He fixates a point between the two as if he were looking through the card at a distant object, moving card in and out if necessary, and notes what is seen. (2) He brings the card up close to the face, keeping the eyes still fixated for distance, and notes what happens.

Results. *Subject's report.* Give an account of the number of images in (1).

Discussion of results. How many images were seen on the first distant fixation? After moving the card, how many were seen? Why did the two central images combine? How did the combination image appear as to relief and distinctness? (Note that the combination image was made from both eyes.) How do you explain the relief shown? Did the combination image appear as if the smaller or the larger end of the cone were nearer the eye? Which is associated with much convergence, a near or a far object?

Suppose that each drawing was located in proper position to represent the cone as it was seen by the right and the left eye (that is, the right-eye drawing on the left and the left-eye drawing on the right); when the two drawings were combined, as in the middle image (Fig. 29), theoretically should you see that image as you saw the original cone — with the smaller end toward you — or with the larger end toward you? (*Hint.* Refer back to see if the right-eye image was on the right or on the left. Also note in the fixation of the distant object whether the images are crossed or uncrossed. It is necessary to have clearly in mind under what conditions the right-eye image is on the left (crossed) and vice versa.)

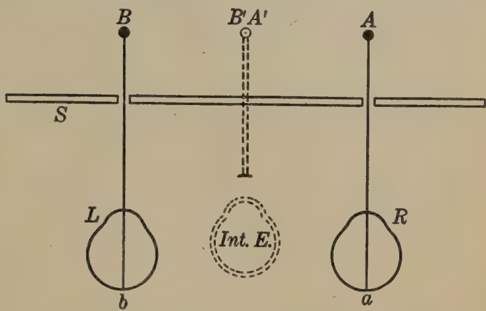

FIG. 29. The effect of binocular projection of images

S, screen; *B* and *A*, real objects; *B'A'*, combined and projected images of *B* and *A*; *Int. E.*, assumed position of interocular eye; *L*, left eye; *R*, right eye; *b* and *a*, centers of left and right retinas respectively

Did your observation agree with those in (1) and (2) of *B*, 3? Did the resulting fusion give you a perception of the cone with large or with small end toward you? Does this result agree with theory?

In obtaining the original drawings from the cone with the small end toward you (thereby requiring more convergence) which was more displaced to the left in the right-eye image, the large or the small circle? which to the right in the left-eye image? If the large circle were nearer, how would the small circle appear displaced? What arrangement of the two image drawings gives (1) relief with small end of cone near, (2) with small end more distant? Why?

These theoretical variations should all be verified by observation.

5. The Stereoscope and the Perception of Depth.

Material. Any available stereoscope; the sketches used in 4, *e*, copied in india ink and mounted side by side on a card that will fit the stereoscope; chart; other stereoscopic slides (a hand stereoscope with Titchener's Series of slides amply illustrates the principle shown).

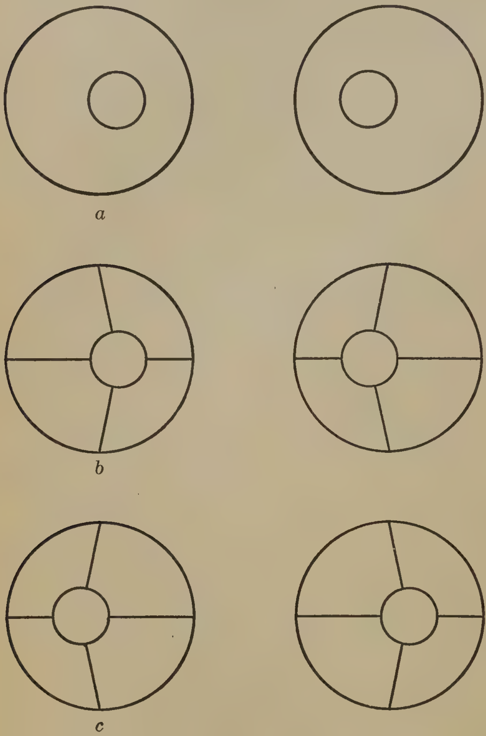

FIG. 30. Images of cone as seen with each eye separately

a and *b*, after fusion, small end near observer; *c*, after fusion, large end near observer

Procedure. S examines the sketches in the stereoscope and also a number of the stereoscopic slides.

Results. Subject's report. Describe the effect of the stereoscope.

Discussion of results. Do you get a clear sense of perspective? How does the image appear in size as compared with the object? In the light of what has been worked out in previous experiments, explain the principle of the stereoscope. In what school subjects would the stereoscope be of value?

Fig. 29 may be used to explain fusion as observed in the experiments above.

The two eyes are in parallel position for fixation of a distant object. *A* and *B* represent two similar objects. Rays of light from these points fall on corresponding points of the retina; a single binocular perception results and the combined image of the two points is located in the visual field in a line straight out from the nose halfway between the eyes. If the objects are alike or nearly alike, there is fusion. If they are different, the stronger prevails and is superimposed on the weaker field

(see the hole through the hand). It is as if there were a cyclopean eye in the middle of the forehead.

C. Muscular Activity of the Eye in Perception of Three-Dimensional Space (One Student).

1. Accommodation.

Material. Pins; black card 12 cm. by 5 cm.; meter stick; supports; corks.

Procedure. (1) *Eyestrain in changing from far to near accommodation.* S holds a forefinger before one eye, the other being closed, and looks past the window at a distant object, noting the clearness or diffuseness of the two images, finger and object. Now he looks at the finger with the distant object in the background. As he fixates the finger, he notes especially any sensation of strain around the eye as compared with sensations when the distant object was fixated.

(2) *Effect of too near accommodation on clearness of object.* S closes one eye and looks at a pin, which he holds 35 cm. from the other eye. He moves the pin slowly toward the eye, noting clearness of image. When it comes within about 15 cm., what is the appearance? Is there a feeling of eyestrain? He pricks a hole in a black card, holds the card close to the eye, and looks through it at the pin 15 cm. away, noting the clearer appearance and change in size.

(3) *Accommodation for near points.* S pricks in the black card two holes about 2 mm. apart, and, holding the card close in front of the eye with the two holes horizontal, looks through the holes along the meter stick (supported at a convenient height) at a pin stuck in a cork about 40 cm. from the eye. Fixating the pin, S moves it along the stick toward the eye until he sees two images. He notes the distance from the eye as the near limit of accommodation.

2. Convergence and Accommodation.

Material. Meter stick; supports; printed page; wire gauze 15 cm. square.

Procedure. S supports the wire gauze about 45 cm. from the eye and the printed page about 25 cm. beyond on the meter stick. He focuses (converges) the eyes first upon the printed page so that he can read the print, and then upon the wire gauze, and notes any sensation of strain, trying to determine whether near or far focus is more difficult and locating as well as possible the strain.

Results. *Subject's report.* Where is eyestrain situated? Does more strain result from accommodation to near or to far objects? Remembering that the more convex a lens, the shorter its focus, explain the mechanism of accommodation and diffusion circles, using diagrams. Why did the pinhole cause a clear image? Considering that

contraction of the ciliary muscle causes convexity and relaxation decreases convexity, would more eyestrain be experienced in near or in far accommodation? How does eyestrain contribute to space perception? Is much convergence an accompaniment of near or of far accommodation? What effect, then, does convergence or non-convergence have upon perception of space?

General discussion. After consulting the references below and the foregoing experiments, do you think that far or near objects present greater differences in appearance when viewed with the two eyes alternately? What suggestion as to its distance would you receive from an object whose relief was very apparent? from one whose relief was little noticeable? What is the effect of double images on distance? Do distances appear greater on clear days or on days when the atmosphere is hazy? Why? How does the rate of motion of a railway train sometimes suggest its distance? Does it cause greater eyestrain to view a near or a distant object? How, then, can eyestrain serve as a measure of distance? Why are size, color, light, and shade more effective in suggesting relief in painting when viewed with one eye? Mention as many secondary aids to the perception of distance as you can. What are some psychological factors in visual perception of space? Give three practical applications of principles involved in perception of visual space.

Inferences. *a.* Give a clear statement of the part played by the muscular activity of the eyes in the perception of three-dimensional space.

b. Give a clear statement of the factors involved in visual perception of three-dimensional space.

READINGS. **2**: 141–152; **6**: 311–312, 315–317; **8**: 28–40; **10**: 178–188; **12**: 323–339, 343–344; **14**: 175–197; **15**: 178–180; **17**: 262–267; **18**: 303–322; **20**: 1124–1127, 1132, 1135–1136; **24**: 137–144; **25**: 252–257; **27**: 308–320; **29**: 109–153; **31**: 173–194.

EXPERIMENT 75. To study Kinæsthetic Perceptions of Space

A. Perception of Horizontal Linear Space (Two Students).

Material. Meter stick.

Procedure. E places the meter stick on a table in front of S (who is seated) so that its center is in S's median plane. S places the forefinger of his right hand on the center point and closes his eyes. E lifts the finger vertically 2 or 3 cm. and moves it to the right, placing it on the stick at a distance of 20 cm. from the first position. He then lifts it again, S carefully noting in both cases kinæsthetic sensations

all the while, and moves it back to the starting-point. S now tries to repeat the out-and-in movement with eyes closed. This is repeated ten times, E always placing S's finger at the proper position on starting the movement out. The same experiment is tried with a distance of 35 cm. S must maintain a constant speed and make no corrections. He must not be aware of his results, as his eyes are to be kept closed.

Results. The results may be tabulated in the following form:

TABLE XXXI. TWENTY-CENTIMETER MOVEMENTS

TRIAL	MOVEMENT OUT	MOVEMENT IN	ERROR OUT			ERROR IN		
			+	−	Per Cent	+	−	Per Cent
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

A similar table should be made for the other distance tried.

Was there any tendency to turn the head or the eyes? Did you feel sure of the distance? How accurate does kinæsthetic perception appear to be from this experiment? Does the movement in as a rule agree more nearly with the movement out or with the distance attempted? Give in figures the accuracy of the kinæsthetic perception in this experiment, using the averages of the two tables for a final average. Quote results published. Can you devise a similar experiment for movement of the whole body through a large distance? Discuss your results as to the relative accuracy of the out and the in movements.

B. Perception of Vertical Linear Space (Two Students).

Material. Meter stick.

Procedure. The procedure in this case is similar to that in part *A*, except that the meter stick is clamped in a vertical position before S with the zero point on the table and the movements are vertical.

Results. Tabulate results as in part *A*.

Discussion of Results. Which perceptions were more accurate, horizontal or vertical? How much more? Compare the two as to

tendencies for overestimating or underestimating the distance. Take as an illustration the operation of turning on an electric light in a familiar dark room; how would the accuracy of your movements compare with the accuracy of movements from the same point when the room was lighted? Can you give an example from your common experience of the rôle played by kinæsthetic perception in reproduction? Why is the actual performance of a movement the best way to learn to reproduce it in memory?

Inference. The inference should be a summary of what has been learned from the experiments above.

READINGS. 2: 146–152; 4: 260–269.

EXPERIMENT 76. **To study Perception of Filled and Unfilled Space**

A. Tactual Perception (Two Students).

Material. Eleven pins; a strip of soft wood about 10 cm. long, 5 mm. to 7 mm. wide, and 5 mm. thick; another small piece of wood; compasses.

Stick nine pins 1 cm. apart in the wood strip so that the heads are in an even line of 8 cm. in length. By means of the soft wood fix the other two pins in the compass arms after removing the compass points.

Procedure. S lays his forearm on the table, palm up, and closes his eyes. E presses the row of pins in a lengthwise direction against the forearm just above the wrist, being careful to place it so that all pinheads touch the skin at the same time with equal pressure, and holding it long enough to give a contact sensation. E next applies the compass pins in the same manner a little to one side of the place before touched, taking care that the heads come down upon the skin in the same direction and at the same time, having previously set them the required distance apart. E may first separate the compass pins several centimeters more or less than the standard distance for filled space (8 cm.). S is asked to judge whether the second distance is equal to, greater than, or less than the filled distance. If the distances do not seem equal, the distance of the compass arms is altered and the procedure repeated until S finally reports an equality. The error, which is the difference between the filled and unfilled distances, is recorded by E in the "+" or the "−" column, according to whether the unfilled space is overestimated or underestimated. E should have an equal number of "+" and of "−" measurements. Ten records are made.

This experiment should be very carefully tried, as it is difficult for some subjects, although clear for others.

Results. Construct a table, giving plus and minus errors, average, and percentage of illusion, using the millimeter as the unit.

B. Visual Perception (One Student).

Material. See Fig. 31.

Procedure. Taking the space *b* as standard, S compares it with *a* and *c*. With *f* as standard, he compares the sides of *d* and *e* with it, and also the whole spaces inclosed.

Results. Subject's report. Give your judgments and comparisons with actual lengths.

Discussion of results. How may the effect be explained here? Reconcile the results in parts *A* and *B*. Devise an experiment for

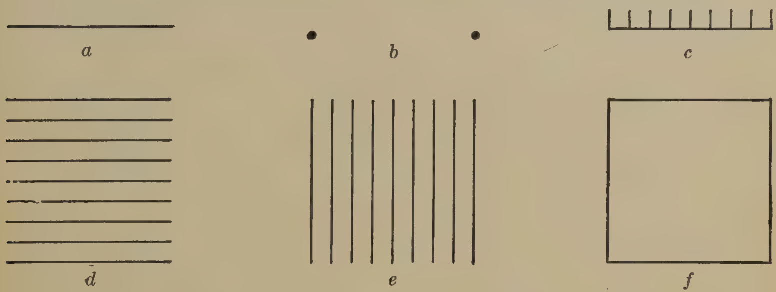

FIG. 31. Lines and squares for comparing filled and unfilled visual space

filled and unfilled time. How does time appear in retrospection? Give an everyday example of these illusions.

Inference. State the law of filled and unfilled space.

READINGS. **2**: 153; **17**: 283–284; **18**: 329–331.

EXPERIMENT 77. To study Accuracy of Motor Expression of Visual Perception (to draw a Line Equal to a Given Line) (One Student)

Material. Card with a line 100 mm. in length; sheet of paper; millimeter ruler; pen full of ink; thumb tacks; drawing-desk or drawing-board.

Procedure. S places the card with the standard line on the upper end of the drawing-desk and a sheet of paper on which equal lines are to be drawn just below the card. S judges carefully the length of the standard line and reproduces it at the top of the paper, moving his pen at a uniform rate and with a continuous motion. He folds under that part of the paper containing the line just drawn and draws a second line in exactly the same manner, proceeding thus until ten trials have been made.

Results. Measure each line very carefully with the millimeter scale and record on it its length in millimeters.

In the table below, the deviation is the difference between each measure and the average, the error the difference between the measure and the standard. Find the average of the deviations (A. D.), the average error, and the constant error, the latter being the algebraic sum of plus and minus errors divided by the number of errors.

TABLE XXXII. JUDGMENTS OF LENGTH AND ERRORS

TRIAL	MEASURE	DEVIATION	ACTUAL ERROR
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Average		A.D. =	Average error = Constant error =

Also construct a frequency table showing distribution of errors for the class. From this table construct a graph showing the frequency distribution of the errors.

Did accuracy increase? To what causes do you ascribe your errors? What effect might have been found in your results if you had seen each line you had drawn all the time? Was the tendency of your error plus or minus? What was the tendency of the class error? What errors were more frequent?

READINGS. 5: 179–182.

EXPERIMENT 78. **To demonstrate the Existence of the Blind Spot and to show how Each Eye supplies the Deficiency of the Other (One Student)**

A. To demonstrate the Existence of the Blind Spot.

Material. Meter stick or yardstick; card, 4 in. by 10 in., bearing a black disk $\frac{3}{4}$ in. in diameter at a distance of 4 in. from the center on the right and an oblique cross $\frac{3}{4}$ in. to the left of the center; screen-holder; support stand.

Procedure. S holds the yardstick horizontal, one end resting just beneath the nose against the upper lip and the other on a support. The card is placed in the screen-holder about 8 in. from the face, having the black disk on the right. S closes the left eye and moves the screen-holder slowly away from the face, keeping the cross fixated until the black disk just disappears. He then records this distance, after which he moves the screen-holder until the disk just comes into view. The second distance is recorded. The difference between the two measurements is recorded as the depth of the blind spot. Five records are taken and the average recorded as the depth of the blind-spot area.

Results. Subject's report. Record the five sets of measurements in tabular form with final average.

Discussion of results. What is the area and shape of the blind-spot projection as given by standard authors? Why is it so large when the spot in the retina is only a point (1.5 mm.)? Since the cross is fixated, light from it will fall upon what part of the retinal area? What is the cause of the blind spot? Devise a method for mapping the shape and size of the blind-spot projection area.

B. To show how One Eye supplies the Deficiency caused by the Blind Spot of the Other.

Material. Card, 4 in. by 12 in., having in the center a black fixation cross and at a distance of 4 in. on the right and left, respectively, a red and a black disk;[1] a small black card 2 in. by 4 in.

Procedure. S holds the card at arm's length with cross straight out from root of nose. With the left eye closed, and fixating the cross in the center, S moves the card toward the face until there is a change in the field of vision. Then, keeping the card stationary, he closes the right eye and opens the left, and notes any change in the field. Still keeping the card stationary, he brings up the small black card and moves it, holding it edgewise against the nose (keeping both eyes open and hence seeing both disks), until there is a change in the field of vision.

Results. Subject's report. With the questions below as aids, and by the use of a diagram, write out a clear explanation of how one eye supplies the deficiency of the other.

Discussion of results. Why do we not perceive the blind spot as a hindrance to vision? Would a person who had vision in only one eye be conscious of blind-spot effect? Who discovered the blind spot?

[1] It has been found convenient to use cards containing black and red disks, as described here, since they can more readily be made in the laboratory for large classes than the house and tree cards.

Since both eyes are fixated on X, on what point in the retina of each eye will a line from X fall? (Fixation determines the position of the eye globe.) Since the blind spot is always nasal, note its different position with respect to this point in the right and the left eye. In the diagram, from which disk do the rays of light come that fall upon the point of clearest vision in the right eye? in the left eye? What is

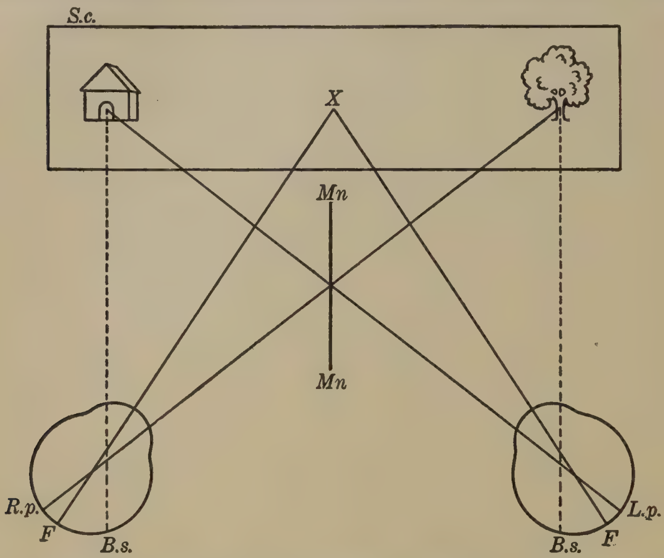

FIG. 32. Relation of each eye's object and position of vertical card when each eye sees the object in the other eye's blind spot

Mn, screen card; *B.s.*, blind spot; *S.c.*, stimulus card; *L.p.*, left eye's picture; *F*, sensitive spot; *R.p.*, right eye's picture

the effect of the small card upon these rays? From which disk do the rays come that fall upon the blind spot in the right eye? in the left eye?

Inference. Give as inference the two facts found.

READINGS. **27**: 88, 328; **28**: 62–63; **29**: 48–50.

EXPERIMENT 79. **To study Illusions of Perception (One Student)**

A. Illusions due to Habit. 1. Aristotle's experiment.

Material. Small marble.

Procedure. S takes the marble in the palm of his left hand. Crossing the index and second fingers of the right hand and closing his eyes, he touches the marble with the crossed fingers, moving

them so that the marble will touch at the same time the opposite surfaces of the two fingers. The position is varied until the one marble appears as two. Spread the arms of a pair of dividers and, holding the prongs so that they touch the index and second fingers of the right hand, note the sensation of oneness.

Results. Subject's report. Record observations in the two cases.

Discussion of results. In the ordinary position of our fingers, how many marbles would be necessary to touch at the same time the outer surfaces of the two fingers? the inner surfaces of the two fingers? How do we explain the illusion? Give as many examples as you can of illusions due to habit. How do you explain the transfer of motion from a moving railway coach close by to the coach in which one is sitting? How do these illusions illustrate further the discussion of the component parts of a percep-

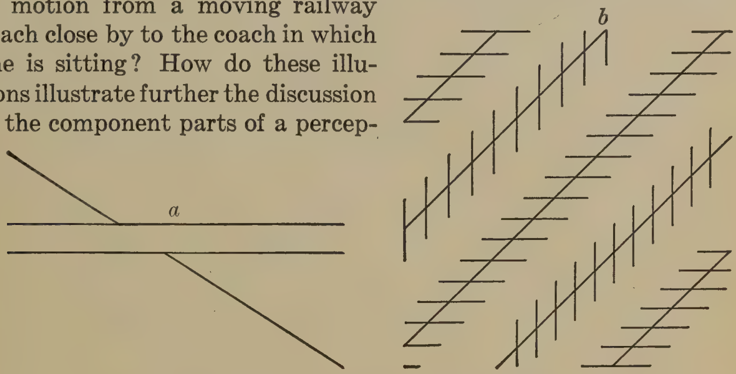

FIG. 33 A. Two forms of line illusions

a, Poggendorf's illusion; *b*, Zollner's illusion

tion as given in Experiment 68 (p. 163) of this chapter? With which of the components of perception are these illusions concerned?

2. Habit: Judgment of Angles.

Material. Two sets of parallel lines (*a* and *b* in Fig. 33 A).

Procedure. Observe carefully with the eye the direction of the oblique line in *a*. Make a dot on the left of the two parallel lines where you think the oblique line should cross. Measure your error. The apparent oblique lines in *b* are parallel. Place your pencil at the end of the middle apparently converging line and draw a line parallel to the adjacent line on the right. Measure in millimeters the error your line makes with the adjacent line. What line shows the extent of error?

Results. The results consist of the errors in millimeters.

Discussion of results. How are these figures illustrations of habit? We naturally tend to overestimate acute angles and underestimate

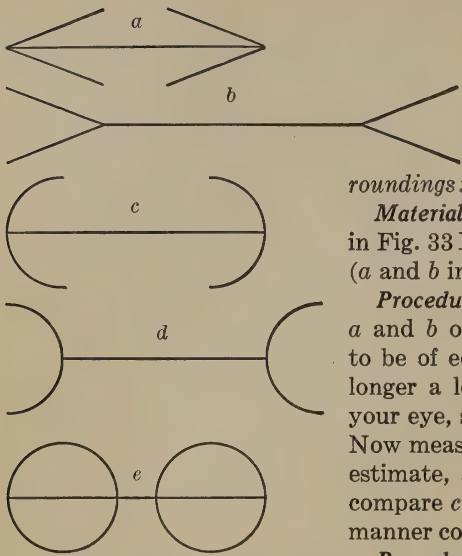

FIG. 33 B. Several forms of Müller-Lyer illusion

obtuse angles to make each nearer to the right angle. On this assumption explain the two figures.

B. Illusions due to Surroundings: Contrast and Confluxion.

Material. Equal lines (*a, b, c, d, e* in Fig. 33 B) and two equal segments (*a* and *b* in Fig. 33 C).

Procedure. If the horizontal lines *a* and *b* of Fig. 33 B do not appear to be of equal length, lay off on the longer a length which, according to your eye, seems equal to the shorter. Now measure the two lines and your estimate, and record the error. Also compare *c* with *a* and with *b*. In like manner compare *d* and *e* in Fig. 33 B.

Procedure. Make an estimate with the eye and with compasses to determine the apparent and the real relative size of the two segments *a* and *b* in Fig. 33 C.

Results. Make a record of measurements.

Discussion of results. Can you explain from the literature on the subject what causes the apparent difference in length between *a* and *b* in Fig. 33 B? Give a general explanation which will cover *a, b, c, d,* and *e* in the same set. Are these illusions common to all normal persons?

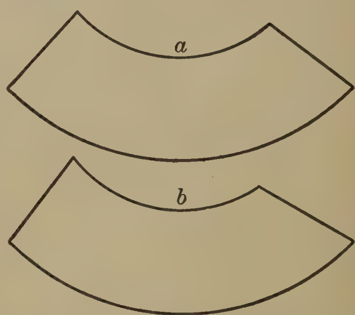

FIG. 33 C. Illusion of equal areas

General discussion of illusions. Why may perceptions of an object be unlike the sensations which that object excites through the sense organ? What kind of sensations are ignored or neglected? Illustrate your answer. What are the two factors which unite to form the perceptual basis of experience? To which of these factors is illusion due? When does an illusion arise? Give example. What are illusions? According to the view of perception taken in the preceding

pages, would the hallucinations of delirium tremens be considered as perceptions? To what class of mental phenomena do hallucinations belong? Why are they so objective and so vivid? To what class do dreams belong? How is the norm or standard size of an object formed in experience? Distinguish between an illusion, a hallucination, and a perception. How do hallucinations resemble perception? How do they differ?

If possible, give an account and explanation of an illusion or a hallucination that has come within your knowledge. What other senses besides vision give hallucinations and illusions? Give examples. Of what value are illusions in the interpretation of mental life?

READINGS. **3**: 46–72; **4**: 291–297; **21**: chap. vi; **23**: 115–121; **28**: 167–173.

EXPERIMENT 80. To study Size-Weight Illusion. De Moor's Illusion (Two Students)

Material. Pair of scales; dish of shot; three canisters of same shape and weight but of unequal size, weighted with shot, with

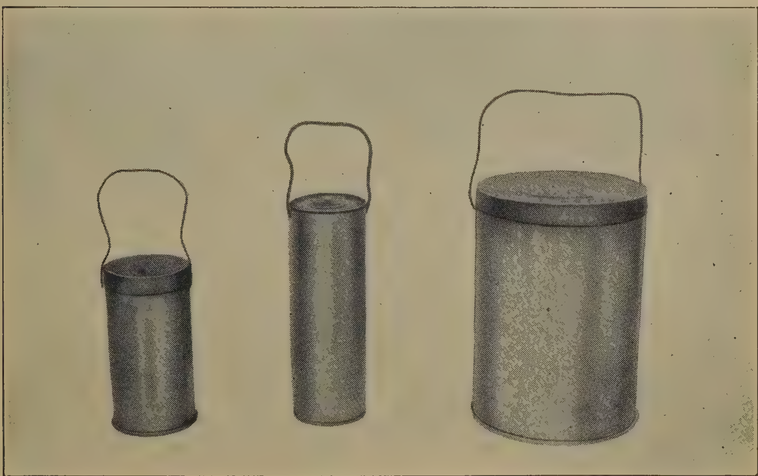

FIG. 34. Size-weight illusion

cotton batting to prevent rattling. Each canister is provided with a handle made from the same wire; the wire is shaped so as to present a horizontal form at the point of lifting (see Fig. 34).

Procedure. 1. S is blindfolded. The boxes, beginning with the largest, are presented in turn to S, who lifts them by the index finger from the same spot at the same rate and to the same height. There should be three-second intervals between liftings. The second weight lifted is regarded as the compared weight, and the judgment is "equal," "lighter," or "heavier." The three are again compared by presenting them in the opposite direction, beginning with the smallest. It may be necessary to repeat the liftings in both directions two or three times. S now opens his eyes and is requested to arrange the three canisters according to their apparent weight. The order of lifting must be the same as that when blindfolded.

2. Each canister weighs 300 g. E now requires S, with eyes open, to again compare the canister judged to be the heaviest with that judged the lightest and then to fill the heavier of the two until they are judged equal. E now weighs the larger one and records the amount in grams by which it exceeds the smaller in actual weight. Repeat this procedure four times so that five records are available.

Results. Experimenter's report. The results may be reported in the form of the table below.

TABLE XXXIII. EXCESS OF ESTIMATED WEIGHT IN SIZE-WEIGHT ILLUSION

TRIAL	OVERESTIMATE	VARIATION
1	20.5	1.9
2	19.5	.9
3	16.0	2.6
4	10.6	8.0
5	16.6	2.0
Total	83.2	15.4
Average	16.6	3.08

Discussion of results. Does your table show a gradual decrease in the amount of the illusion? What number in your table indicates your average error in estimation? How does the size of an object affect the amount of muscular energy necessary to lift it? How does this experiment show that the output of muscular energy depends upon vision? How does expectancy of apparent difference in the weight of the two canisters tend to produce an illusion? Why was S blindfolded in procedure 1?

READINGS. **17**: 206–209; **23**: 98; **29**: 20–21.

EXERCISES

1. A democrat and a republican went to get the election returns. They saw the same numerals flashed on the screen, but each went home maintaining that his own party had won. Explain.

2. When asked by his mother what time he came in the night before, a young man replied: "Plenty minutes past ten." The mother appeared satisfied. What were the probable attitudes of both mother and son? How were they aroused? What is the relation of perception to attitude here?

3. Perception may be conceived as an integration (see 4: 250). According to this principle explain the following: on entering a very dimly lighted room you perceive a person sitting by the fire, though you get only enough details to see a head over the back of an armchair and a flickering light. Give other examples of reaction to a large stimulus pattern brought out by stimulus from a part of the pattern. Show how this principle may be applied in Experiments 71 A and 71 B.

4. In a camp the constant sound of a cowbell was heard early one morning. When the campers arose, the sound seemed to be nearer and was finally located as the slow, steady drip of water on the tin cover of a pail. What was in the stimulus pattern of the dropping water to bring out the reaction pattern of the cowbell? Why would that particular sound be more likely to appear in a camp on a farm than at home in town?

5. A child dreamed that she was sinking down into the bottomless pit of Hell; it seemed ages that she was going down, down. Suddenly she hit the floor, and on waking found that she had been sliding out of bed, confined by the covers, so that her fall was gradual. Describe this as (1) a dream perception, followed by (2) a waking perception. What were the probable stimuli, both internal and external, for these perceptual reactions?

6. Why may a painting (the "Mona Lisa," for instance) appear to the ignorant person, with no artistic training, no better — perhaps much less beautiful — than a colored chromo of no artistic merit, whereas the trained artist can study the painting for hours and find food for thought and inspiration? Apply the principles of perception in your answer.

7. Which can better act as proofreader, the author of a manuscript or one unfamiliar with it? Justify your answer.

8. "It has been estimated that only two-thirds of the incidents in any event are reported, and of those that are given only 66 per cent of the details are accurate." Give some of the factors in perception which lead to such inaccuracy.

9. Why can one better see color, as well as some other details, in a painting when it is looked at upside down? Show that this contributes to the theory of pattern reactions.

10. A young girl who was in a somewhat nervous state one night heard a heavy step on the tin roof of the porch just outside her window. The step approached and her window was shaken; it receded and the window of the adjoining room was shaken. This kept up distinctly until she was almost paralyzed with fear. At last she arose and by a great effort went to the window and opened the blinds. The wind was blowing heavily and she saw that the rattling of loose tin had caused her perception. What form of perception is this? Give an example of a similar occurrence, mentioning the common element which caused one part of a stimulus pattern to arouse a different reaction response.

11. A young woman, who was recovering from a severe illness, had just heard of the death of a dear friend. She suddenly awakened one night and in the moonlight distinctly saw her dead friend sitting quietly in a chair by her bedside. She saw details of her dress and of her expression, all of which were natural and as she remembered them in life. Nothing was indistinct. It was a vivid perception. But in a few moments, as she was trying to speak, the figure vanished and the chair was empty. She felt absolutely certain that she had seen her friend, not in a dream, but in a waking moment. Note all conditions and explain the perception. What is such a perception called? How does it differ from the perception of the preceding exercise?

12. Give examples of three occurrences like that described in Exercise 11 which have come within your observation or experience. Give any occurrences recounted to you as supernatural which you can place in this class of phenomena.

13. From your study of perception how should you explain the voices and visions of the Maid of Orleans?

14. In copying long numbers from one sheet to another why can one make fewer errors if one calls the numbers aloud?

15. Show how it was a statement entirely accurate from a scientific standpoint, according to the laws of temporal perception, even if somewhat embarrassing to the bride, when the groom remarked at

the end of the first week of their married life, on their return from a trip, "This has been the longest week I ever spent."

16. A small child who was called "Sitter" (Sister) by her family was visiting in the country, and attended with her parents a revival meeting. The preacher made a dramatic appeal and, pausing at the end, said with great earnestness, "Sinner, when are you coming home?" The little girl thought he was calling her and, much impressed with the honor, piped up with great distinctness and a Southern accent, "Să-ăd-day." Account for this in terms of perception.

17. "With the dropping of a little word from another's hand into mine, a slight flutter of the fingers, began the intelligence, the joy, the fullness of my life" (Helen Keller, *The World I Live In*, p. 6). Explain this as symbolic perception. Does it differ from perception in hearing the spoken word or seeing the written word? Connect the above with a later statement in the same book (p. 159) that the author had no power of thought up to that time, and tell what seems to be the relation between thought and the perception of language.

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CHAPTER VIII

LEARNING

1. It is assumed that the reactions of an organism, its modes of behavior, furnish not merely the criteria for our objective determination of the learning processes of the organism, but that these reactions constitute the means by which the learning takes place. — S. S. COLVIN, *The Learning Process*, p. 1

2. One must, however, differentiate two types of development: development as growth or maturation, and development as learning. — KURT KOFFKA, *The Growth of the Mind*, p. 38

3. Probably all forms of learning can be reduced to one relatively simple, schematic type: Reception of impressions through the senses; assimilation, analysis, and combination of processes in the mind; and redirection of impulses to produce a reaction. — DANIEL STARCH, *Educational Psychology*, p. 115

TOPICAL OUTLINE

Nature of Learning
- *A*. Function
  - I. To acquire and organize experience
  - II. To develop power for adjustment to a changing environment
- *B*. Content
  - I. Objective: achievements of the race — scientific, political, artistic, moral, industrial, literary
  - II. Subjective
    - 1. In mental terms: attitudes, purposes, ideals, knowledge, sentiments
    - 2. In neural terms: permanent modifications and the integration of neurones into reaction systems

Analytic Aspects of Learning viewed Objectively
- *A*. Stimulus, situation, problem
- *B*. Learners
  - I. Classes
    - 1. Lower forms of animal life
    - 2. Domestic and wild animals
    - 3. Human child
    - 4. Adult
  - II. Mechanisms
    - 1. Receptors (sense organs)
    - 2. Conductors: receiving, coördinating, controlling, and distributing neural systems
    - 3. Effectors: muscles, glands, supplementary parts

- III. Capacities
  - 1. Perceiving
  - 2. Discriminating
  - 3. Selecting
  - 4. Coördinating
  - 5. Expressing
- *C*. Responses
  - I. Sensorimotor
    - 1. Connecting an innate or acquired movement with a new stimulus
    - 2. Connecting an old stimulus with a new movement (learning names of objects)
    - 3. Developing skill in highly complex reactions
  - II. Associative (accompanied by selective and inhibitive reactions)
    - 1. Perceptual
      - *a*. Learning to react to an object
      - *b*. Learning to react to a symbol
      - *c*. Learning to react to a relation
    - 2. Memorial
      - *a*. Imagining
      - *b*. Remembering
  - III. Expressive
    - 1. Feeling
      - *a*. Nature and composition
      - *b*. Relation to other responses
    - 2. Emotional (innate and learned aspects)
    - 3. Sentimental
      - *a*. Nature and composition
      - *b*. Permanency and rate of growth
    - 4. Volitional
  - IV. Problem-solving
    - 1. Relation to other forms of learning
    - 2. Trial and success
    - 3. Reasoning
      - *a*. Relation to associative reactions
      - *b*. Relation to innate reactions
      - *c*. Types of reasoning
    - 4. Conceiving and ideating: plans, purposes
- *D*. Results from responding
  - I. Habits: hierarchy of, personal, social, ethical, vocational
  - II. Skill: coördinating, eliminating (short-circuiting), facilitating (transfer of learning)
  - III. Mental responses
    - 1. Vividness in perceptual and imaginal processes
    - 2. Speed and acuity of discrimination
    - 3. Speed and accuracy in recognizing and in judging
    - 4. Power to perceive means and relations between them
  - IV. Developed in intelligence, organized information (knowledge), and cultural sentiments

V. Changes in the learner
  1. Strengthening the loose mechanisms involved in sensorimotor responses: manual skill
  2. Developing connections between specific objects and neural patterns of the brain and their corresponding effectors: perceptual learning
  3. Integrating neural systems between sensory and motor areas of the brain: attitudes, tendencies, sentiments (moral, social)
  4. Developing power to discriminate, compare, select: differentiated motor responses
  5. Developing power to draw inferences, conceive principles, and to predict consequences

Methods of Learning
  A. Trial and success
    I. Law of exercise
    II. Law of effect
    III. Function of inhibition
  B. Imitation
  C. Instruction

INTRODUCTION

Learning as a process produces changes in function and changes in content (**2**: 250–252, 503–509). The former changes consist in modifying the learner's responding mechanism, of whatever sort, by means of the interaction between the learner and his environment, changes thus wrought form in their ensemble the modes of acquired behavior. These modes are referred to as discrimination (**29**: 143), perception, judgment, skill (**29**: 253–263), intelligence, reason, etc. If the learner increases his power to respond to relatively smaller amounts of stimuli, his behavior is more discriminative; if the responses are modified so as to improve their speed, accuracy, and ease of action, they form skillful behavior; if the learning increases the power to respond with more ease and precision to symbolic stimuli (for example, words, figures, signs, and emblems), perceptual, conceptual, and associative behavior has been improved; if the changes increase the learner's ability to make variable responses in the interests of appropriate or more difficult adaptations to a changing environment, the individual's intelligence has been developed; and, finally, if the changes increase the power to select and adapt means to the solution of problems and of difficulties, and to control responses by their foreseen

results and consequences, rational behavior, the crowning achievement, has been developed.

Coördinate with the functional changes of an organism are those of content, referred to as facts, information, knowledge, or what not. "The man of learning," "A little learning is a dangerous thing," "Much learning doth make thee mad" are descriptions of learning viewed as content. Changes in both content and function are always involved but by no means in the same proportion. When learning involves merely the acquisition of skill, changes in function are dominant, whereas learning tables of denominate numbers, or the paradigms of a verb, or the names of the presidents in order of service produces changes in content. If the psychological description of the differences between content and function is exchanged for one in terms of neural conditions, then content refers (1) to lessening the resistance at the synapses, and (2) to the integration of the reaction arcs into larger and larger systems, and function means the ease, accuracy, speed, and intercoördination and control of neural action.

The analysis of learning viewed objectively reveals four interrelated parts: (1) situation, stimulus, condition; (2) the learner; (3) the learner's responses; and (4) the results of the responses. A study of the interaction of these factors under experimental conditions serves to keep their causal relations prominently before us and to maintain vantage points from which to observe the laws of human behavior. Direct observation of the interaction between stimulus and response reveals the principle of cause and effect and thereby opens the way for a prediction of human behavior based upon scientific grounds (**30**: 9–15). One person learns Lincoln's Gettysburg Address sentence by sentence until the whole can be recalled without prompting; another learns it by reading it repeatedly from beginning to end until unaided recitation is possible. The psychologist predicts from an established law that the second person will learn the address more readily and will retain it longer (**8**: 289–292). Experimental studies of the capacities and mechanisms of the learner have led (1) to the formulation of

laws of responses, and (2) to the discovery of instruments for measuring the strength and quality of the responses. The laws of psychophysics — laws of attention, of memory, etc. — illustrate the former, and mental tests in common use are concrete examples of the latter (**3**: 345–371).

Responses furnish the chief source of facts about human nature. By them the teacher appraises the act of his instruction, the physician diagnoses the patient, the judge renders his decision, and the psychologist infers both the stimulus and the results. Responses are variously classified, depending upon the purposes of the author. When their manner of origin forms the chief interest, they are classified as either innate or acquired. When their objective and subjective character or their obviousness or hiddenness to observation is in question, they are referred to as explicit and implicit. When the problem of degrees of consciousness is the center of interest, the responses are termed conscious, marginal, and unconscious (**32**: 265–267). When the gross character of the mechanism involved in the response is the main question, they are classified as (1) organic, (2) vocal, (3) body or muscular, and (4) sense organ. This latter group refers to responses that adjust the sense organs to stimuli and that change stimuli to neural impulses. From such adjustments are derived our perceptions of space, of time, of rhythm, and of properties of objects. When there is an unequal use of the sections or links of a reaction arc in learning, the responses are named according to the most active section; thus, when receptors and effectors are most active (**32**: 527), the responses are termed sensorimotor (**29**: 287–288); when the neurones of the brain form the largest section, the responses are called associative; when muscles, glands, and vital organs are the most active parts, the responses are termed expressive; when associative, inhibitive, and facilitating neurones are the most active parts, the responses are referred to as problem-solving, volitional, and control.

Learning of any sort starts with reaction arcs already formed; these may be either innate (that is, formed by growth processes and independent of experience) or acquired (**32**: 296–302), and

very often both may be used in the same problem, as in learning to read, to draw, or to catch a ball. Simple reaction arcs, like those of the wink, patellar reflex, and swallowing, may be termed *active*; whereas arcs that control the human ear, the ring finger, and certain muscles of the face, and in various pathological conditions, are more or less *dormant*. Again some arcs are *potential*, or unformed, waiting to be developed. These several classes of arcs influence the type of learning. Usually innate arcs and those expressing fundamental desires set problems for control; all dormant arcs furnish problems of rejuvenescence and relearning, the latter being confined to persons who have been injured or are suffering from arrested development; potential and acquired arcs set complicated problems of coördination and inhibition and are always met with in learning industrial and skillful arts.

The results of learning are the evidence that it exists. Several methods have been devised for expressing the rate in learning. They fall roughly into two general classes, qualitative and quantitative. Rate of speed and amount done are expressed numerically, and elimination of error, ease of execution, improvement of technique, and lessening of fatigue are expressed in qualitative terms. In a more fundamental sense all estimates of results, both quantitative and qualitative, are descriptive, the former being more exact and refined (27: 116 ff.). The results of learning add immensely to the complication of the psychology of learning, and for that reason the mastery of methods for their estimation is quite essential.

The experiments which follow furnish opportunity to study the kinds of responses, methods of learning, and ways of expressing results.

Experiment 81. **To study Sensorimotor Learning: the Conflict of Impulses (Two Students)**

Material. Mirror 6 in. by 8 in.; cardboard screen about 12 in. by 8 in.; five sheets of paper 6 in. square, each having a drawing of a six-pointed star; ten blank sheets of the same size; thumb tacks; graph paper; support for screen; clock.

The set-up of the apparatus is shown in Fig. 35; *CL* is the cross line next to the mirror *M*. The screen *S* is about 8 in. above the hand.

The star pattern may be made of cardboard or paper by placing the material under one of the stars given, pricking a pinhole through the vertices of each of the twelve angles, and connecting these points on the cardboard with straight lines. The star thus traced is cut out and used for a pattern.

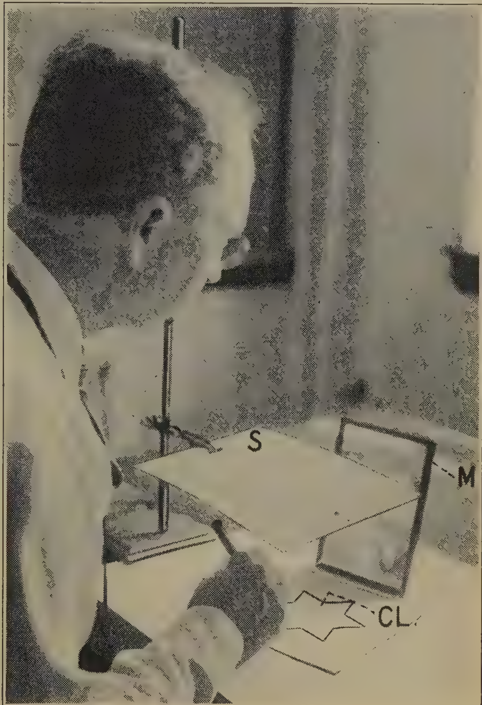


FIG. 35. Set-up of apparatus for sensorimotor learning

Procedure. E fastens a star to the table or drawing-board so that the cross line is directly in front of the mirror and places the screen so that S can trace the star by seeing it in the mirror only (see Fig. 35). The points of the star should be numbered clockwise, beginning with the one at the right of the cross line. At the signal from E, S begins to trace the lines of the star, going clockwise from the cross line and continuing until the starting-point is reached, being careful not to lift the pen from the paper and not to see the process except in the mirror. E keeps time as indicated by the clock for the drawing of each star. As soon as the star is finished, S writes "Hardest" and "Easiest" at the points where he had most and least difficulty in tracing. Continue the tracings in like manner until S has completed fifteen stars, after which E and S exchange places. E should insist that S keep on the line and that a constant effort be made to return to the line at once when off of it; S avoids drawing a line parallel to the star ray. E records S's time in seconds

on each sheet as soon as it is completed, and S makes notes on the back of the star to assist in subject's report.

Results. *Subject's report.* Give an account of the difficulties, inhibitions, and methods of overcoming them. Preserve the fifteen tracings of the star, numbered in order, with a record of the most and least difficult parts, time required in seconds, and number of errors. Each movement away from the line is counted an error, with the understanding that S has adhered strictly to the conditions.

Experimenter's report. Tabulate results, showing in two parallel columns the time in seconds for each drawing and the number of errors.

Construct two graphs on the same cross-section paper, placing the number of the trial on the horizontal line (abscissæ) and the number of errors and time in seconds on the vertical line (ordinates). Study the drawings and find what directions, toward or from the body, are most difficult and what ones are least so, vertical or oblique, right or left.

Discussion of results. What effect has the mirror upon direction? How does this direction in the mirror compare with the direction S purposes to take? What are the two conflicting impulses thus aroused? Why should the conflict be greatest at certain points? If S finally, in the fifteenth trial, does the tracing much better or perfectly, which impulse has become dominant? What has S learned to do in terms of coördination of eye and hand? Why can we call this sensorimotor learning? What is the method of learning here used? Give an example of this method in the motor life of the child. What association is here overcome, and what new connection is made? How may this action be considered as an act of the will? Does this experiment depend on intelligence?

This experiment was used, among others, with excellent result as a test for the conservative and radical in the presidential election of 1924 (see Henry T. Moore, "Radicalism versus Conservatism," *Journal of Abnormal Psychology*, Vol. XX, July, 1925). Explain how the trait of conservatism or radicalism (fundamentalism or modernism) might be indicated in the results of this experiment.

As a study in the rate of learning observe the curves for the following points: How is progress shown in both curves? Do errors decrease with rate of drawing? Are there any indications of periods of rapid and slow learning? Explain your answers to the last question.

READINGS. **24**: 1–72; **25**: 34–40; **31**: 119–132.

EXPERIMENT 82 A. **To study Acquisition of Motor Skill: Coördinating Potential and Active Reaction Arcs (Spacing Method to be Used) (Two Students)**

Material. Sling shot; target; several rubber balls 1 in. in diameter.

The sling shot is made of a forked stick of convenient size and two rubber bands $\frac{1}{2}$ in. wide, each fastened to a prong of the stick by means of rawhide strings or strong leather. The rubber is reënforced by a leather band where the ball is held by the fingers while subject is aiming (see Fig. 36). The target is made of black oilcloth,

FIG. 36. Apparatus for target practice

on which are painted five or more concentric white circles 1 in. wide and 1 in. apart; or it may be made by simply chalking concentric circles on a blackboard, renewing them as they become blurred. Before each shot the balls are dipped in flour.[1] The left hand, holding the forked stick, grasps the support rod (Fig. 36), and the right is left free to adjust and release the ball when properly aimed.

Procedure. Adjust the support rod to suit S's standing height and at a distance 10 ft. straight in front of the bull's-eye. Much of the success in scoring depends on the skill in aiming and releasing the ball. The mark left on the target by the ball is the score. Draw through the bull's-eye a vertical and a horizontal line, dividing the

[1] A target made of soft board to which are thrown feathered darts is sometimes used for this experiment. The authors have not found this material successful.

entire target into quadrants. Call the vertical line y and the horizontal line x. Two measures are made for every score: (1) the distance from the x line above being plus and below minus; (2) the distance from the y line left being minus and right plus (Fig. 37). Six subjects, each with an experimenter, may be assigned to the problem. At the conclusion of the practice, each couple presents its results to the class. The following order of practice is recommended:

Pair *A* makes 300 shots in 12 days at 25 per day
Pair *B* makes 300 shots in 10 days at 30 per day
Pair *C* makes 296 shots in 8 days at 37 per day
Pair *D* makes 300 shots in 6 days at 50 per day
Pair *E* makes 300 shots in 4 days at 75 per day
Pair *F* makes 300 shots in 2 days at 150 per day

The practice may be made every day or every other day. E and S exchange places during the practice period, each having a turn.

FIG. 37. Guide lines on target to aid in computing constant error

Results. The rate of progress may be shown in at least three ways: (1) by the increase in the number of shots approaching the center, (2) by the average of the sum of the errors for all the shots during the practice period, and (3) by the constant error, or the center of actual distribution of all the scores in a given period. The results of a typical period of twenty-six shots are given here (Fig. 37). The errors were recorded in inches; the average of the sum of the errors for twenty-six trials is 13.4 in. The constant error for the x series is the algebraic sum of -7 in. and $+6.6$ in., or -0.4 in., and that for the y series is the algebraic sum of -13 in. and $+8.6$ in., or -4.4 in. The cross in the diagram is located by the intersection of the x line (-0.4) with the y line (-4.4). Thus the center of the actual distribution of all the scores is a measure of two factors: (1) the distance from the bull's-eye and (2) the direction. The amount of error should be measured by E after each shot.

The following headings may be used:

Trial	x Series		y Series	
	Below (−)	Above (+)	Left (−)	Right (+)

Discussion of results. Name the probable reaction arcs that were coördinated in learning to hit the target. Which time interval corresponds to the most rapid rate of learning as expressed in your graphs and in the differences between the amount of the initial and final errors? Upon which does space learning have a greater effect, the acquisition of skill or logical learning? Plan and perform an experiment that will give evidence on this question.

READINGS. **3**: 162–170; **6**: 144–204; **12**: 183–190; **23**: 354, 371–373; **41**: 254–264.

EXPERIMENT 82 B. To study Acquisition of Motor Skill in Opposition to a Specific Innate Mechanism (to control the Reflex Wink)

Material. Headrest; apparatus as shown in Fig. 38.

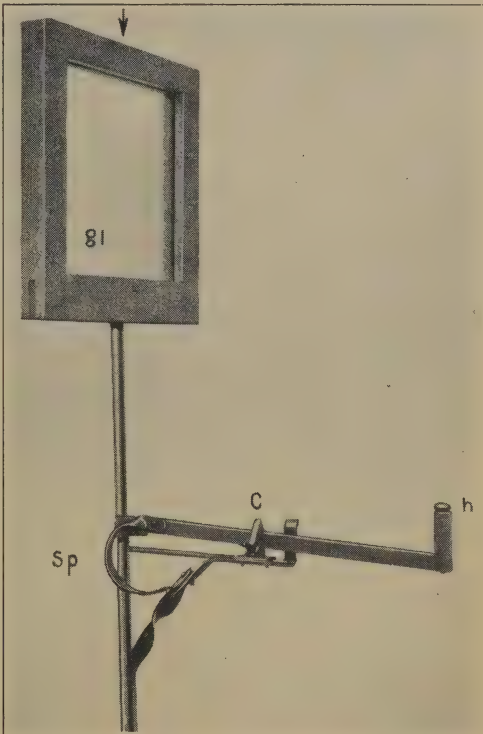


FIG. 38. Apparatus for studying control of reflex wink

The apparatus consists of a thick frame of wood 1 in. deep, having at the top an opening through which a pane of heavy plate glass is slipped, the glass fitting into lateral grooves $\frac{1}{2}$ in. deep. The frame is fastened firmly to an iron rod. A wooden hammer (h) with a rubber tip is fastened to the rod below the frame. At C is a catch which,

when pressed down, releases a steel spring (*Sp*) so that the hammer flies up and strikes the glass at its middle point.

Procedure. S seats himself comfortably in front of the apparatus, which is clamped at a convenient height. He places his head in the headrest, bringing his face so near the glass plate that the tip of the nose nearly touches its center. E stands beside him and releases the catch, noting all attempts at control of the wink. First a series of twenty trials is made so that S's natural wink processes, without special effort, may be seen. After a rest of ten minutes another series of twenty trials is taken in which S is directed to contract the muscles of scalp and face, particularly around the eyes, and to concentrate on thus inhibiting the wink. After a rest of ten minutes another series of twenty trials is made in which the same performance is repeated, and in addition S plugs his ears. These two latter series are carried out for three or four days (unless it is found that the inhibition becomes perfect before this period), and records are made by E.

Results. *Experimenter's report.* The record is made by E for one period as follows:

$$W = ? \qquad P = ? \qquad I = ?$$

W means wink; *P*, partial wink; and *I*, no wink, or complete inhibition.

Discussion and comparison of results of Experiments 82 A *and 82* B. In which of these problems are the arcs active? In which are they potential? Which offer problems of control? Which offer problems of coördination? Give examples of learning in the arts and industries similar to the conditions in Experiment 82 A. What other innate mechanisms, more or less similar to the reflex wink, may be brought under voluntary control.

READINGS. **12**: 300–316; **19**: 188–189; **26**: 201–226, 232–252.

EXPERIMENT 83. To study Learning by Association — involving the Substitution of Letters for Digits

Material. Exposure apparatus (see Fig. 16); timepiece; list of 20 words and 20 cards with words expressed in digits; prepared tables and key to the words.

Each experimenter is furnished with (1) a key containing the letters of the alphabet from *a* to *i* inclusive, together with the equivalent digit for which each letter is to be substituted (the digits from 1 to 9 are not placed in regular order with the letters; for instance, *a* is not equivalent to 1, nor *b* to 2); (2) a numbered list of twenty

words and the equivalent number made of the digit substitutes, that is, the material to be learned (for instance, if $a = 9$, $b = 6$, $d = 1$, the word could be "bad" = 691); (3) a pack of twenty cards bearing the numbers which correspond to the twenty words on the list. For E's convenience each card may be numbered with a small pencil mark at one corner to correspond to the number of its word in the list of equivalents. On the other corner in ink may be written "A," which shows that the card belongs to Series A. There is a corresponding series for the second student to use, Series B. This makes use of letters *m* to *u* with *w* substituted for *q*, and the same digits, 1 to 9.

Procedure. S is seated on one side of the upright and E on the other side, having before him, but concealed from S by the partition, the list of words with equivalents, the key, and the twenty cards stacked in the same order as the list. E explains to S that he is to respond to the number on the card by a word containing as many letters as the number has digits, and that in the end, after the twenty cards have been used, he will find the letters which stand for each of the nine digits respectively. He will then have learned to associate each letter with its proper digit. At signal "Ready" E exposes the first card by placing it on S's side of the upright. He notes the time. S attempts to discover the word expressed by digits, bearing in mind that it must be spelled by letters from *a* to *i* only. He makes as many attempts as necessary until the correct one is given, each time writing on a piece of paper visible to E (instead of speaking, so as to avoid giving information to those near by) the word he supposes to be the correct one. Every attempt must be written and no slightest guess kept from E. E signifies whether the word is correct or incorrect and takes the time from exposure to the writing of the correct word, entering this time and the number of attempts in the proper place in the table. E removes the card from view as soon as it is identified. This process is continued until the results have been entered for the twenty cards. This process makes one complete *period.* The process is now repeated from the beginning in the same manner, except that the cards are now shuffled. But E is careful to record the results opposite the same card in all periods; that is, if in the second period the first card happens to be number 6, the record should not be entered opposite number 1 in the table but opposite number 6, thus enabling S to compare progress with any card in all periods. The process for an entire period is repeated until the twenty cards are learned; that is, until only one trial is given to each and that without hesitation. E and S now exchange places, and Series B is used.

Results. The table may be arranged in the following form:

TABLE XXXIV. LEARNING BY ASSOCIATION

Card	Time in Seconds for Each Period						Number of Attempts						Remarks
	I	II	III	IV	V	etc.	I	II	III	IV	V	etc.	
1 . . .													
2 . . .													
3 . . .													
4 . . .													
5 . . .													
.													
.													
.													
20 . . .													

Discussion of results. When the digit stimulus is given, what response do you learn to make? Is this an example of a substitute stimulus or a substitute response? What new habit has been formed here? Give some principles by which it has been established. What was the method of learning here? What were the chief difficulties in the problem? What were the chief aids to learning? Give an explanation of this process in terms of nerve physiology as presented in standard texts.

Inference. Formulate a law of learning from your results.

READINGS. **8**: 50–59; **9**: 223–226; **27**: 125–136; **31**: 133–150; **32**: 398–405.

EXPERIMENT 84. Studies in Associative Learning (Two Students)

A. The Effect of Meaning on Associative Learning.

Material. Stop watch or clock with second hand; cardboard 10 in. by 12 in.; a number of cards, 6 in. by 8 in., on each of which are drawn ten objects in two horizontal rows of five each. The words should be covered during the experiment.

A sample series for each pair of students is suggested by Series I, Sets *a*, *b*, *c*, and Series II, Sets *a*, *b*, *c*. (These figures may be used, provided, of course, that each student agrees not to inspect the other's series.) Each student, in drawing his own series of objects, should keep the areas on the card occupied by the objects uniform in size and the lines forming the objects of uniform heaviness. Each experimenter keeps his series in an envelope and removes a card only when it is time to expose it to S.

Procedure. E places card *a* (bearing 10 objects) of Series I, the easiest of the set, on the table before S and covers it with the cardboard. At signal "Ready" he exposes the card for ten seconds only. The card is covered again, and S at once draws the objects on the record blanks in the same position in which it appears on stimulus card. These papers must have S's name, the date, and the number of the trial. Draw as many objects as possible and then write on the back of the record sheet a brief report of the aids used in making the reproduction. Drawing the objects and writing the report should not consume more than ten minutes and may be done in less. Keep the time intervals between trials as constant as possible. Use a new sheet of paper each time for the drawing until all the objects are *correctly* reproduced. The last paper must show all the objects correctly drawn and in proper position. E and S now exchange places and Set *a* of Series II is learned in the same way. As soon as Set *a* of each series is done, Set *b* of Series I is begun under the same conditions of learning and continued until ten trials have been made. E and S exchange places and make ten trials of Set *b*, Series II. Less meaningful cards usually require more than ten trials, but if more than ten are required for complete learning, they should be performed at the next laboratory period. When both students have finished Set *b*, the most difficult set, Set *c* is next learned, which completes the procedure of part *A*. During the learning process no drawing is counted until it is exactly correct in form and position.

Results. *Subject's report.* S now takes charge of his own record sheets and arranges and expresses the facts in three ways:

1. By a report. S reads the notes made on the back of the record sheets to determine what was characteristic of the learning in each of the three sets of objects, respectively. If geometrical figures were used in Set *a*, were they remembered by name or by shape? Was meaning attached to the nonsense figures? If so, give illustration. Did you name any of them, and why?

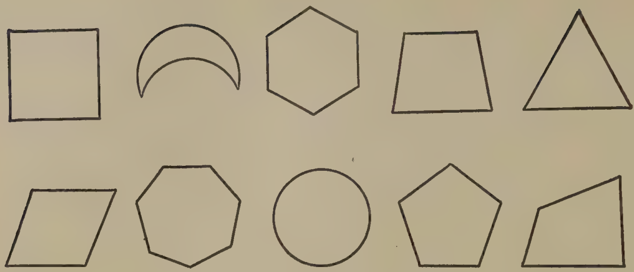
2. By a table. The table may be arranged as in Table XXXV.

3. By graphs based upon the table. Draw each of the three graphs from the same base. Let the base line (abscissæ) show the number of trials and the ordinates the number of objects drawn correctly at each trial.

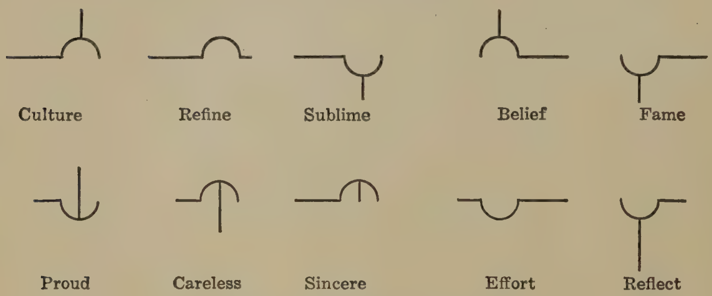
Discussion of results. Before writing your inference, read and answer the questions raised in paragraphs *a* and *b*:

a. Examine the subject's reports for these points: (1) aids to writing and drawing the figures, such as grouping and classifying as to similarity and contrast of figures, position on the card, association

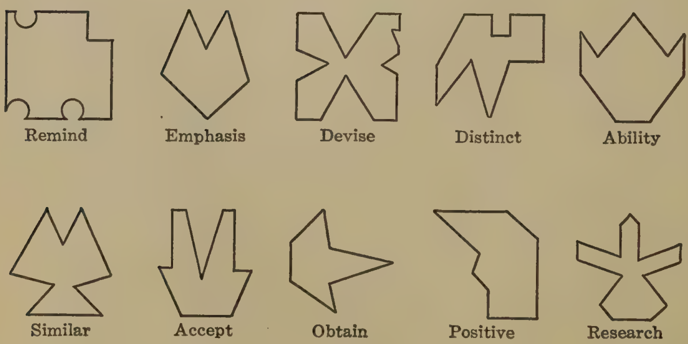
SERIES I



Set *a*. Meaningful figures



Set *b*. Less meaningful figures



Set *c*. Nonsense figures

FIG. 39 A. Series for associative learning

SERIES II

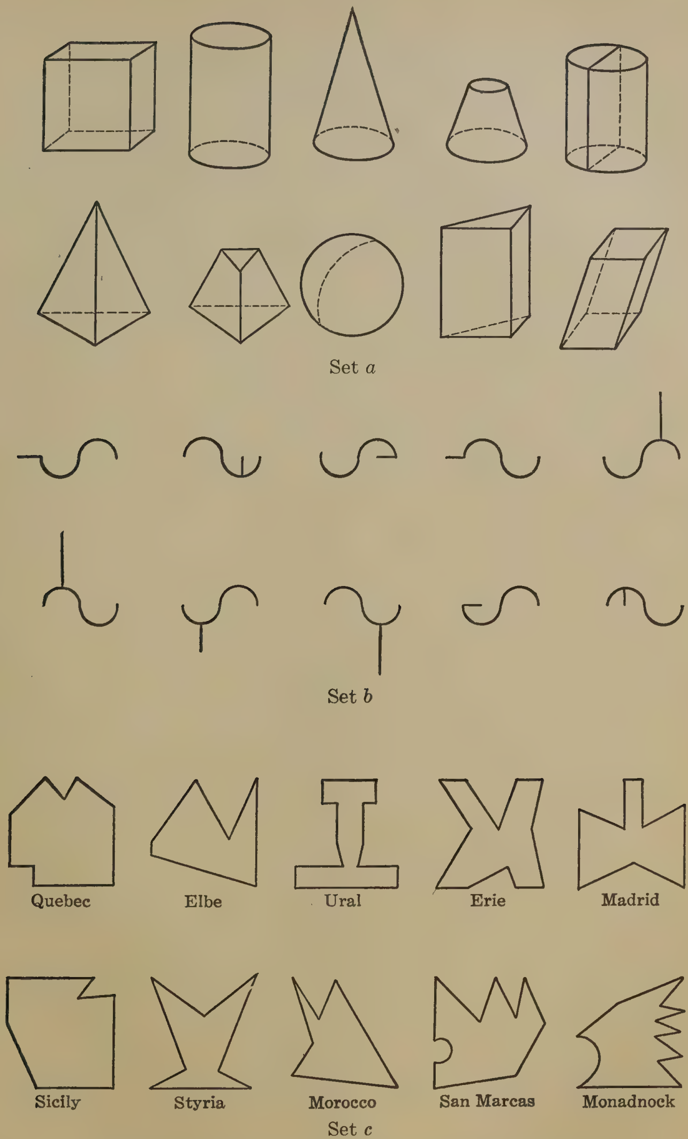


FIG. 39 B. Series for associative learning (*continued*)

TABLE XXXV. EFFECT OF MEANING ON RATE OF LEARNING

TRIAL	SERIES I					
	Set *a*		Set *b*		Set *c*	
	Number Attempted	*Number Correct*	*Number Attempted*	*Number Correct*	*Number Attempted*	*Number Correct*
1						
2						
.						
.						
.						
10						

with familiar objects, concentration on difficult figures; (2) methods of reproduction, such as drawing the figures in the air, assigning names and repeating them, making rimes and rhythmical descriptions; (3) causes of forgetting between the trials and between the periods, such as distractions, fatigue, mood, attitude, and inhibitions (can you classify the inhibitions?); (4) nature of objects that proved difficult and of those that were comparatively easy.

b. Let the number of repetitions required to reproduce the objects of maximum meaning be taken as the unit of comparison. Then that number divided by the number of repetitions necessary to reproduce all the objects of any one of the other cards expresses the ratio of meaning for that card in terms of the card of maximum meaning. To illustrate from results of a similar experiment, it was found that 4 trials were necessary for the reproduction of 16 letters, 20 for 16 geometrical figures, 51 for 16 nonsense figures, and 59 for 16 conventional curve-line figures, forming practically the following ratios: geometrical figures, 1:5; nonsense figures, 1:13; and curve-line figures, 1:15.

Inference. What inference do the graphs tend to support about learning objects of different degrees of meaning? What sort of objects offer difficulties to discrimination? When you make a discrimination between two objects, have you reacted to both? If so, how do the reactions compare? Upon what does the capacity for discrimination depend?

B. The Effect of Names given to Objects upon the Rate of Associative Learning.

Material. Stop watch or clock with second hand; two series of cards of four each; cover cardboard 10 in. by 12 in.

Procedure. Each student, E and S, draws twelve figures or objects in three rows of four each on four cards, a total of forty-eight objects.

Although no two are alike, they must be of the same general type suggested in Sets *b* and *c* of Series I and II on pages 216 and 217.

Caution. Keep the areas occupied by the objects uniform in size and also the lines of uniform heaviness; the slightest imperfection in drawing will prove a source of error.

Objects of Set *a* are not given names.

Objects of Set *b* are given nonsense names, as:

kilg	rax	kas	dok
zod	mor	dygt	nir
relk	sught	zol	sab

Objects of Set *c* are given abstract names, as:

serene	demure	candor	destiny
order	gratify	doubt	curious
regular	honor	duty	justice

Objects of Set *d* are given proper names, as:

Arnold	Edward	Alfred	Henry
Thomas	John	Peter	George
Harry	Samuel	Walter	Charles

The words should be written on a typewriter and then each pasted under the object which it names. Keep the sets in an envelope.

Procedure. One subject learns the sets in the order *a*, *b*, *c*, *d*, and the other in the reverse order. The same general conditions are followed as in part *A*, but twelve seconds are allowed for exposure and ten minutes for reproduction, which in this case consists in drawing the figure, writing its name below, and reporting on the reverse side of the record the aids used in making the reproduction. E and S exchange places after every ten trials.

Results. *Subject's report.* As the subject's report in this experiment is very important, due care should be made in writing it on the reverse side of the records, which should be arranged in a coherent form and expressed in at least four paragraphs, one for each set.

Experimenter's report. This consists of a table, as in part A, from which are constructed learning curves for each set of objects. Each curve is drawn from the same base, on which is shown the number of trials. A brief description of each curve should appear in the report.

Discussion of results. It has been shown that names improve discrimination. Can as broad a statement be made concerning the effect on the rate of learning forms of objects? Which set of cards do you make the basis for comparison in judging whether names aid or hinder learning?

Since the objects were of the same difficulty, the difference in the rate of learning was largely due to the *name* factor. Is there any evidence tending to show that names aided in learning the objects? Which class or classes of names proved a positive hindrance? Which class offered the least hindrance? Name the kinds of stimuli involved in learning both the name and its object. Did you do anything to complicate or increase the different kinds of stimuli? If so, what? What law of association is chiefly involved in this sort of learning? Is there any evidence tending to show the effect of practice?

Inference. See how many laws of learning can be given here.

READINGS. **5**: 360–367; **7**: 151, 298; **17**: 222, 229, 239, 243, 271; **22**: 207–233; **27**: 32–35.

A STUDY IN PLACE MEMORY

Place memory occurs in the mental connections formed between words, dates, sentences, pictures, diagrams, etc., and their position on pages. Place memory is constantly used by clerks in retail stores. It serves in the skillful operations of the railway-mail clerk, the central telephone operator, and in distributing printer's pi. The following experiment is designed for studying its manner of growth.

EXPERIMENT 85. To study the Growth of Place Memory of Positions in a Vertical Plane

Material. Stop watch; six decks of playing-cards; roller screen; distributing case; number of blank forms for mapping the case.

Let the outside dimensions of the case be 52 cm. high, 92 cm. long, and 11 cm. deep. Divide the case into fifty-four compartments, having six in the vertical dimension and nine in the horizontal dimension. The boxes should be 9 cm. wide, 7 cm. high, and 10 cm. deep. Incline the bottom of the boxes at a slight angle to prevent rebound of card (see Fig. 40). Stain the case a dead black. Uniformity of labels for the boxes may be secured by cutting off the corners from a deck of cards and using these as labels, sacrificing a deck for this purpose. They may be pasted on or inserted in clips at the upper right or upper left edges of the boxes. For this experiment label boxes for all but the face cards; that is, label forty of the fifty-four boxes. To do this, conceive the boxes of the case as divided into

four groups: an upper and lower right and an upper and lower left group. Let the fifth row of vertical boxes be unlabeled and divide the case into right and left halves. Each quarter then contains twelve boxes, ten of which are labeled.

Stack the forty non-face cards by arranging the suits and the card numbers in a definite order; for example, arrange the suits in this order: clubs, diamonds, spades, hearts; and the card numbers in this order: 8, 3, 10, 2, 7, 9, 5, 4, 1 (ace), 6. The stacked order serves to control the labeling of the boxes, which must be done in such fashion as not to permit two consecutive deliveries to go to the same quarters, nor four consecutive deliveries to go to the four respective quarters in the manner of a "round." These precautions prevent the formation of rhythms and the fusion of boxes through movements of distribution. The aim is to keep the position of each box as individual as possible during the mapping process, and thus approach the conditions of learning space position in industrial life.

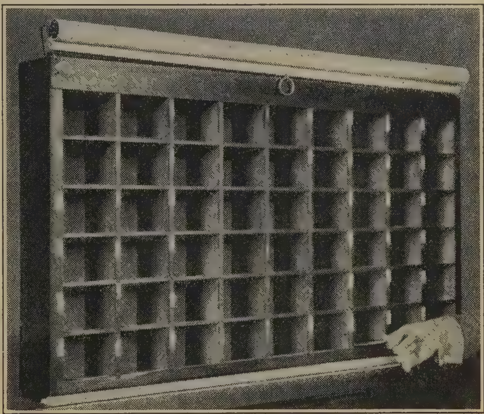


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FIG. 40. Distribution case for place memory

Place the case about 90 cm. from the floor on a stand or desk.[1]

Procedure. S is directed to grasp the stacked deck in the most favorable manner for distribution and to stand directly in front of the case. The signal "Ready" is given, and a moment later the screen is rolled up from the case and the stop watch started simultaneously, and S begins distribution. As the last card is thrown, S calls "Up" as a signal to stop the watch and to pull down the screen. The time between removing the screen and S's signal "Up" is considered the distribution time. S turns at once to charting as many of the boxes as possible on blank forms containing fifty-four compartments arranged in the same way as the boxes of the case. The subject should map the entire forty, guessing if necessary. With

[1] The back of the case may be made of beaver board and the boxes of some soft wood.

the charting finished, the distribution is repeated, followed in turn by further charting on a new blank as before. Consider one distribution a trial, and three a period. Perform one period a day until the mapping is done without error. The opportunity for viewing the position of the boxes is possible only during the exposure and when actually using the case. The charting may be done with or without knowledge of the previous results and mistakes. If the former method is adhered to, learning the position will more nearly conform to the conditions of industrial life. S should write a brief account of the aids which he used in mapping on the reverse side of the map after at least every other trial.

Results. Subject's report. Summarize the methods used for locating the boxes as recorded in notes made on the reverse side of the maps.

Experimenter's report. Arrange the maps in a time series and combine the results in a table with the following headings:

Date	Trial	Rate per Card	Accuracy in Location			
			Correct	One Removed	Two Removed	Scattered

"Scattered" refers to those placed more than two boxes from the proper location.

Construct a second table in which the names (labels) of the forty boxes are arranged in a descending series according to the number of correct *times* each box was located during the mapping. To the right of each name indicate both the absolute number and the percentage of times the box was correctly placed. Those boxes that were mapped correctly at every trial should be ranked 100 per cent and the remainder according to percentage. For example, if twelve trials were required to complete the map and if 10 of clubs was placed correctly twelve times, 9 of hearts ten times, and 3 of diamonds nine times, the rankings would be, respectively, 100 per cent, 83.3 per cent, and 75 per cent.

Discussion of results. Does the table give evidence of a perseverative tendency of a marginally conscious influence operating in learning the positions? If so, in what does it consist? Is there a correlation between the rate of distribution and the number of boxes mapped per trial?

From a study of the second table find answers to the following questions: What is the position of the cards that were listed at 100 per cent? between 95 per cent and 85 per cent? between 85 per cent and 75 per cent? between 75 per cent and 50 per cent? below 50 per

cent? What law may be inferred from these facts as to the growth of place memory? In which quarter of the case were the majority of the boxes first located? In which next? In which last? Can you account for this order? Can you indicate any practical application of the laws that you have formulated to the industrial arts and to teaching? Can you devise further experimentation in the study of place memory? What would be the effect, for example, of arranging the boxes in concentric circles?

READINGS. **10**: 134–166; **13**: 276–283; **17**: 286, 306.

EXPERIMENT 86. To study Transfer and Inhibition in learning Skillful Movements (Six Students)

Material. Ten decks of playing-cards; stop watch; two distribution-cases like that used in the preceding experiment; blanks for recording time per card, giving date and number of trial.

Playing-cards commend themselves as suitable experimental material on account of their cheapness, their accessibility, and their standard shape, size, and slipping quality. It is obvious that the card symbols, color, and numbers make it possible to set a variety of useful laboratory exercises on the acquisition of motor skill, inhibition, transference, and associative learning.

Procedure. Two of the six students are experimenters throughout the experiment, and the rest are subjects. E 1 conducts Plan I of the experiment, and E 2 conducts Plan II. Each plan has Part 1 and Part 2; it is in the latter that the facts of both transference and inhibition are most striking. The plans have much in common and the small difference presents no difficulty in conducting the experiment. The signal is given, the screen is rolled up, and S's distribution time is taken as in Experiment 85.

STACKING THE CARDS

That habits of movement may be formed as soon as possible, the cards must be stacked in the same way for every distribution. For Plan I let the suit order of the cards be hearts, spades, clubs, diamonds and let the numerical order of the cards be Q, 5, 6, 4, 3, 10, 8, 2, K, 9, 7, J, A. For Plan II the order of the suits and the numerical order of the cards are the same as for Plan I. In both plans hearts and diamonds are thrown to diamond boxes and clubs and spades each to their respective boxes. It is well to have stacked an extra deck in excess of the number used per period.

Labeling the Boxes in the Case

The order of labeling the case, together with the order of suit and the order of stacking, gives control over the movements as definite as that formed in typewriting, piano-playing, etc. In the present experiment S will soon discover a set of left-to-right rhythmic movements.

The case for Plan I is labeled as shown in Chart A; these labels of the case in Plan I remain the same throughout Parts 1 and 2.

The case for Part 1, Plan II, is labeled the same as the case for Plan I, but Part 2 requires the changing of the labels as shown in Chart B below. This change of labels on the boxes, without in any way changing the stacking, produces a system of vertical movements at right angles to those of Part 1.

Changing the Practice

1. Subjects doing Part 1, Plan I, practice at the rate of five trials per period until a maximum speed in distributing has been attained; this will usually be indicated by small gains and frequent lapses. The decks are then stacked in the reverse order — the suit order and numerical order of cards and the box labels remain the same — which, of course, reverses the direction of the approaches to the boxes as well as those in leaving. Practice on Part 2 continues until a second maximum of speed is attained.

2. Subjects doing Part 1, Plan II, likewise practice until maximum speed is achieved. The boxes of the case are then relabeled as shown in Chart B, and the practice is continued as before until an entire pack can be distributed in at least fifty-five seconds. Usually higher speeds are attained.

As the facts of inhibition are observable only during the distribution, it is necessary that E be provided with suitable blanks for making rapid entries. For that purpose an error and inhibition chart is here suggested in outline; it shows the main headings, together with the names of the first thirteen cards in a vertical line to the left. The remaining three groups of thirteen should, of course, be added for a complete chart. The inhibition, as well as the error of the movement, should be indicated by a check opposite the card in the vertical column corresponding to the one in S's hand.

S should state, after each distribution, the name of the card found difficult, what cards were anticipated, what movements appeared smooth, and what ones tense and what ones "jerky." E should

CHART A. BOX LABELS FOR PARTS 1 AND 2 OF PLAN I AND PART 1 OF PLAN II

J D	Q C	J S			7 S	A S	7 D	7 C
9 S	9 D	8 S			2 C	A C	K S	K D
2 D	9 C	2 S				K C	8 D	8 C
10 S	10 C	3 C				10 D	3 S	3 D
4 D	6 D	4 C				4 S	5 C	6 C
5 S	Q S	6 S			J C	5 D	A D	Q D

CHART B. BOX LABELS FOR PART 2 OF PLAN II

A D	7 C	K D			8 C	3 D	6 C	Q D
5 D	A S	7 D			K S	8 D	3 S	6 D
3 C	A C	4 C				7 S	8 S	K C
2 S	J S	6 S				J C	2 C	9 D
10 D	4 S	Q C				9 C	10 C	5 C
Q S	J D	9 S			2 D	10 S	4 D	5 S

FORM FOR ERROR AND INHIBITION CHART

NAME OF CARD	NAME . . . . . PLAN . . . . . PART														PLAN . . . . PART													
	Trial													Total	Trial													Total
	1	2	3	4	5	6	7	8	9	10	11	12	etc.		1	2	3	4	5	6	7	8	9	10	11	12	etc.	
Q H																												
5 S																												
6 C																												
4 D																												
3 H																												
10 S																												
8 C																												
2 D																												
K H																												
9 S																												
7 C																												
J D																												
A H																												
etc.																												

notice changes in S's technique of distribution, the manner of standing before the case, the manner of holding the cards, and the use and control of fingers of the distributing hand.

Results. Subject's report. Indicate elements both of transfer and of hindrance in distributing, the effect of making a mistake on subsequent movements, the probable cause of becoming confused. (A

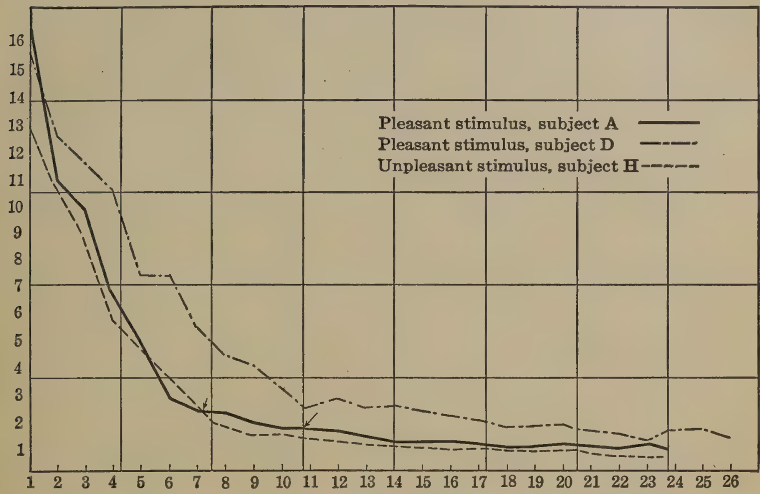
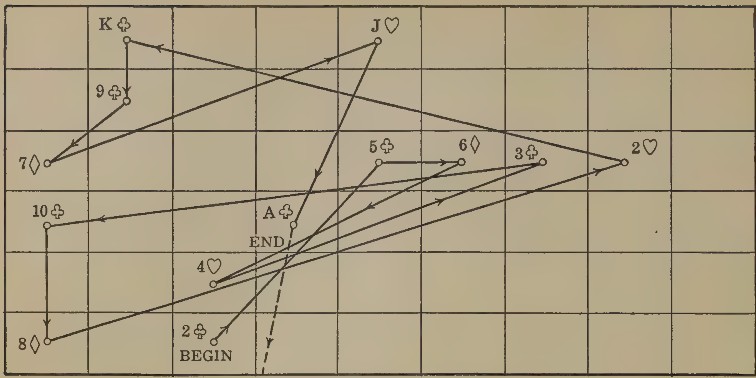


FIG. 41. Graphs showing rate of learning in placing cards in a distribution case

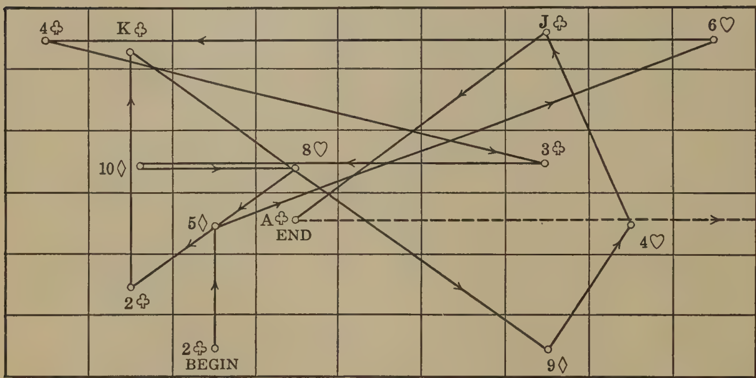
Ordinates show time required in seconds and fractions thereof to deliver a single card. Abscissas show the number of periods of practice. Arrows point to the beginnings of plateaus. (After Kline in *Psychobiology*, Volume II, page 294. By permission of Williams and Wilkins Company)

problem of this sort should stimulate the subject to make observations on managing attention, on the art of anticipation, and on the coördination of diverse systems of movements.)

Experimenter's report. Show the results in tables and by graphs based upon them. The base line of a graph may show the trials or the periods of practice, and the ordinates, the time in seconds per card. The graph above is based upon results obtained in card distribution. Note the two arrows at the "elbows" of the curve. E should look for similar features and indicate what they express. His report should also contain four charts showing an analysis of the movements for each of the four systems of thirteen movements in distributing fifty-two cards. The chart (Fig. 41) shows an analysis of two such systems, the first and the second thirteen. E's charts



PLAN I, FIRST THIRTEEN



PLAN I, SECOND THIRTEEN

FIG. 42. The different systems of movements involved in delivering each thirteen of half a pack of fifty-two playing cards

Note that in the second thirteen the system of movements is radically changed; the third and fourth thirteens (not shown) were equally different. (After Kline in *Psychobiology*. By permission of The Williams and Wilkins Company)

should show why the movements became rhythmic and also the boxes that broke the rhythms and produced inhibitions. The report should also contain an error and inhibition chart.

Discussion of results. What movements in Part 1 aided those of Part 2? List all the factors of Part 1 that were readily transferred in learning Part 2.

Why did Part 2 of Plan I offer comparatively slight inhibition and large transfer? Do the tables, graphs, and subject's report agree on this latter point? What marked inhibitions occurred with all subjects in Part 1 in the same movements? What facts does analyzing the movements by drawing them on a chart offer in explanation of such inhibition? Do these inhibitions tend to stop by giving better attention or by increased practice, or do both play a part? Make a list of all factors that tend to make inhibitions. Should distinctions be made between hindrances and inhibitions?

READINGS. **1**: 4–8; **2**: 173–179; **3**: 323–340; **6**: 352–356; **7**: 211–240; **19**: 194–203; **27**: 393–433; **29**: 491–493.

EXPERIMENT 87. To learn Forms and Patterns by Movements (Two or Three Students)

NOTE. Learning forms and patterns is common to many arts and trades. Tailors, milliners, designers, pattern-makers, and architects must learn to construct and to interpret patterns. Students of design and of art in general memorize in a more or less fortuitous way a sort of artist alphabet, consisting of conventional symbols, figures, and terms. Some information on the ways of pattern-learning has been gained in recent years from investigations made on the learning of the stylus maze. It is interesting to note that these studies were suggested by others made on animals learning to find their way about in intricate mazes.

Material. Two mazes [1] (a right-hand and a left-hand one), sawed from 5-ply wood 1 cm. thick; several dozen sheets of white or cream-white paper, of antique finish, not less than 32 cm. by 32 cm.; stylus pencil, with medium-soft lead, 14 cm. long (Fig. 43), with a rubber button 4 cm. from the tracing end; stop watch; record blanks and tabular forms; drawing-board; thumb tacks.

The mazes are shown in Fig. 43. The outside dimensions are 37 cm. by 37 cm.; those of the maze proper are 30 cm. by 30 cm.; the runways are 1 cm. deep and 1 cm. wide. A square wooden frame 32 cm. high is fastened to the four corners of the maze by long screws put in from the bottom. This frame supports a black curtain on top and around three sides; the rear side is left open for E to observe S's movements. Fig. 44 shows the wooden frame and the manner of covering it. (The maze is exposed in the figure on two sides to show armhole and manner of grasping the stylus; the maze shown in this

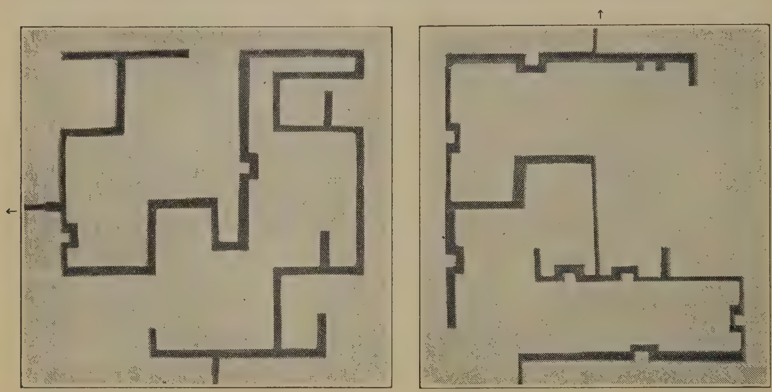
[1] Dr. Willard S. Small, while a student of Professor Edmund C. Sanford in Clark University (1898–1899), was the first to convert the Hampton Court maze into an apparatus for studying the capacities of animals for this type of learning.

The maze shown in Fig. 43 cost $2.65 and was made in a local carpenter shop.

figure is too complicated for class use.) An armhole with a sleeve pierces the curtain on the entrance side; it is thus completely closed from S's view and permits work with open eyes. The apparatus with cover weighs 1400 g. Arrows in Fig. 43 show entrance and goal of the two mazes.

Procedure. 1. Place a sheet of the cream-white paper on the drawing-board and fasten securely with thumb tacks; then place the maze on the tracing-paper and clamp it to the drawing-board. E hands S the following instructions in written form:

Seat yourself before a table upon which the maze is placed, but concealed from view by a black curtain. Take a comfortable and natural position. The maze consists of runways with many blind alleys; one of the runways



Left. Right © H. B. Settle

FIG. 43. Ground plans of left and right mazes

leads to a goal. The problem is to trace through this continuous groove by means of the pencil until the goal is reached. You make a mistake when yo go into a cul-de-sac (blind alley) and will have to retrace to get out of it. Do not raise the pencil from the bottom of the runway at any time, because the lines made by the pencil are important for study.

Start at the signal "Go." Keep on tracing through the runways, regardless of the number of blind alleys entered, until the goal is reached. Hold the stylus in a vertical position; you will know when the goal is reached because you can then move the pencil freely in any direction.

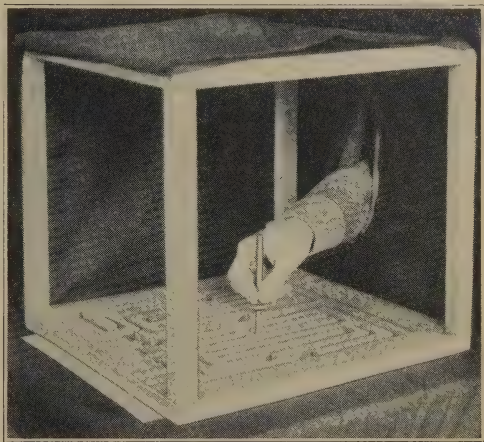
Do not ask any question of the experimenter. Be sure you understand what you are going to do before beginning.

S grasps the stylus just above the rubber button and E places the stylus at the entrance of the maze and then gives the signal to

start. E watches the tracing from the rear end of the frame but refrains from all communication during the process. Tracing from entrance and goal as in Fig. 45 forms a trial. E keeps the time in minutes and seconds. S continues the trials until the maze is learned.

The maze is considered learned as soon as S can make three tracings in succession without a single hitch. S writes on the reverse side of the tracing-sheets a report of difficulties, methods of avoiding them, and ways of learning, but no suggestions are at any time given. E now requires S to make a drawing of the maze from memory. S, at a later laboratory period, learns the maze with the left hand.

2. E and S exchange places and the second subject learns the left-hand maze with the left hand first and then with the right hand, just the reverse of the procedure followed by the first subject. A month after complete learning, both subjects trace the maze a second time from memory. (See Fig. 45 for drawings of three subjects, *A*, *B*, and *C*.



© H. B. Settle

FIG. 44. Stylus maze in use

Curtain raised to show manner of holding stylus

Results. *Subject's report.* This is compiled by S from the records made on the reverse side of the tracings. Similar points and comments made by S are grouped in the same paragraph.

Experimenter's report. Show the progress made, trial by trial, by using a blank similar to the one given here. A "critical point" is a place in the maze where a slight deviation in one direction or another may bring success or failure. Make a careful list of such points and number them 1, 2, 3, etc. Culs-de-sac are similarly numbered. When S fails at a critical point (that is, goes in the direction of a cul-de-sac), a plus sign is made in the record. If he only hesitates, a minus sign is made. If no hesitation, a zero is made. The number of errors and hesitations, respectively, occurring during a single trial is indicated by an exponent to the right of the signs (see Table XXXVI).

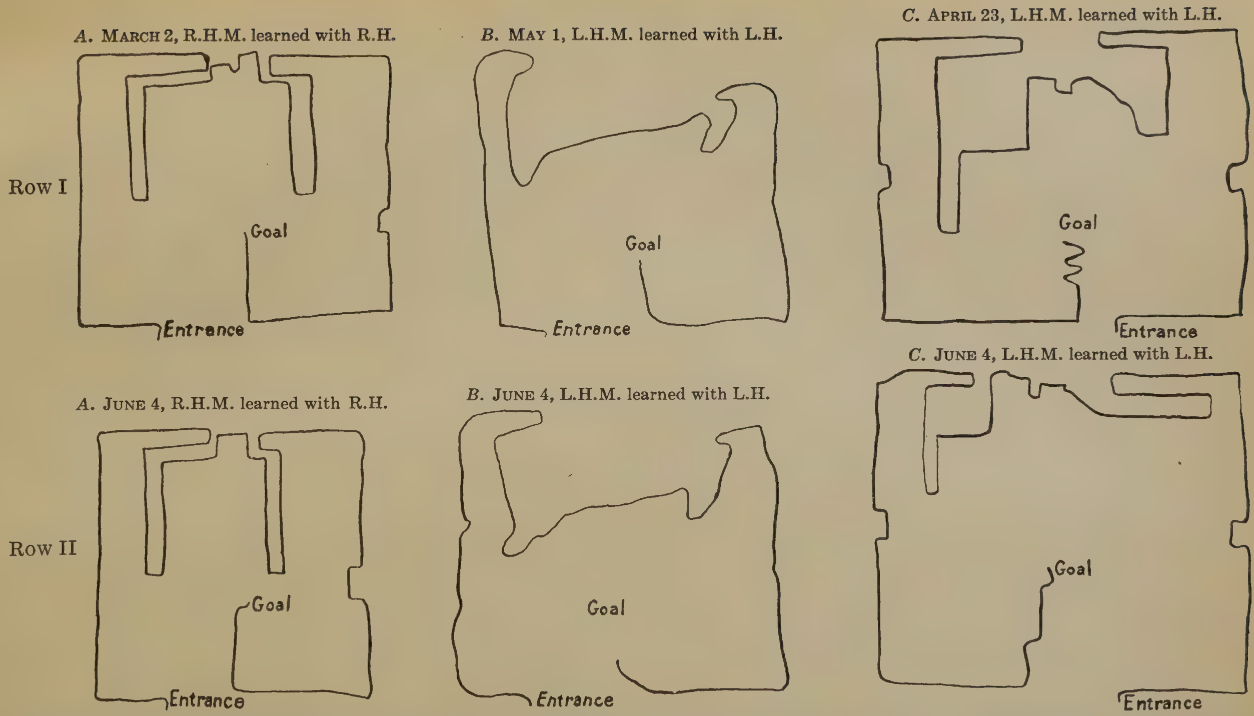


Fig. 45. Patterns of right-hand maze (R.H.M.) and left-hand maze (L.H.M.), drawn as soon as learned (Row I) and thirty-five to ninety-four days after learning (Row II), by subjects *A*, *B*, and *C*

The report should further show learning curves for the right and the left hand and any additional information that will indicate the amount of transfer from one hand to the other. After S has finished learning with both hands E should ascertain by question and from previous observations the methods used by S in learning the pattern.

TABLE XXXVI. RESULTS OF LEARNING MAZE

TRIAL	CRITICAL POINTS											CULS-DE-SAC										
	1			2			3			etc.	Totals	1			2			3			etc.	Totals
	+	−	0	+	−	0	+	−	0			+	−	0	+	−	0	+	−	0		
1 . . .	$+^{3}$	$-^{2}$	0^{2}	$+^{1}$	$-^{4}$	0^{3}	$+^{2}$	$-^{1}$	0^{4}			$+^{4}$	$-^{2}$	0^{3}	$+^{4}$	$-^{5}$	0^{2}	$+^{5}$	$-^{1}$	0^{3}		
2 . . .																						
3 . . .																						
etc. .																						
Totals																						

Discussion of results. Is there any relation between the number of mistakes that occur in the earlier trials and the final rate of learning? Do you find an unmistakable relation between inhibitions and learning the maze? Do the subjects tend to visualize the maze? Is there any evidence that it aided the learning? Are there facts tending to show that vocalization was used? If so, how does its service compare with that of the hand in learning? Do the subjects tend to press the stylus against one side of a runway more than another? If so, how may the tendency be explained? How does the accuracy of the memory drawings compare with S's method of learning? What do these drawings show about the stability of the memory for the maze pattern? What do the later drawings show about the rate of forgetting? How does this rate of forgetting compare with that for dates, events, or other facts?

READINGS. **8**: 238–247; **13**: 259–272; **20**: 3–14, 94–97 (if possible the student should read the entire paper); **21**: 122–154; **24**: 66–67.

EXERCISES

1. Give a concrete illustration of the principle that exercise strengthens a mental connection, that is, that we learn by doing, and one of the opposite, the effect of disuse.

2. Explain the psychology of the "prompting" method of study, that is, testing oneself, then correcting errors, and thus finding what is forgotten.

3. How long, on an average, should one engage in intensive study before resting or changing to another subject? (7: 285)

4. In reviewing for examination is it better to study for a long period the day before the examination, say four to six hours, or to work intensively for short periods with intermissions of rest and entire change?

5. In studying your lessons in history, what method have you found to be best? Criticize your method as to psychological basis and as to economy.

6. Give some advantages of the "whole method," applying it concretely to some of your daily tasks.

7. Which of the following methods is best to use in a lecture course:

a. Take few or no notes, pay very careful attention, trust to memory without writing out the lecture.

b. Take few or no notes, pay very careful attention, write out the lecture shortly after hearing it, referring to notes only when necessary.

c. Take full notes and write out the lecture.

d. Take full notes, trust to notes, and do not write out the lecture.

Investigate this matter for yourself and be ready to report when called upon.

8. Give some uses which may be made of a phonograph in teaching.

9. Study your own learning curve in Experiment 86 and discuss it, referring to (1) initial rise, (2) plateaus, (3) final rise.

10. Discuss the question of interest in learning. What is the affective quality which is present in (or, according to some writers, *is*) interest? Does interest ever occur in connection with the opposite affective quality?

11. Give examples of (1) sensorimotor learning, (2) associational learning, (3) imitation learning, (4) rational learning.

12. Discuss the physiological limit in learning. Is it often reached? What psychological factors may induce a learner to strive for this goal?

13. Take some task you have had and point out the rôle played by the following factors in learning it: (1) intention, (2) attention, (3) understanding, (4) practice.

14. Why is it best, from the psychologist's standpoint, not to refer to notes when giving a public address?

15. A child going into a dark room is frightened by a loud noise. Thereafter the child is afraid of the dark. Explain the association (formed here by shock).

16. A child eats too many green apples. In what two ways, one natural and logical, the other arbitrary, might he be prevented from repeating the act? Give the psychological explanation in both cases.

17. How does the learning of animals differ from that of man? (See **16**: 17, 72, 275–279. Note the explanation of the *Gestalt* theory, that animals perceiving a thing in its setting as a whole do not differentiate and fit the parts into different situations as readily as is done by the higher intelligence of man. How does this explain the fact that a horse can find its way better than a man when lost?)

18. Compare the learning of apes and of children (**15**: 305–306).

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CHAPTER IX

MEMORY AND IMAGINATION

1. All memory is associated with time. Therefore, only those creatures that have perception of time have memory, and memory attaches to that organ (heart) whereby time is perceived. — ARISTOTLE (translated by William A. Hammond, in *Psychology*, p. 195)

2. The word "memory" lays particular stress upon the latency of the "conserved" impressions; "reproduction" and "recollection" upon their recurrences in consciousness. Imagination differs from all three in admitting the possibility of a dissimilarity between the peripherally and centrally excited contents. — OSWALD KÜLPE, *Outlines of Psychology* (translated by E. B. Titchener), p. 170

3. Memory is the knowledge of an event or fact, of which meantime we have not been thinking, with the additional consciousness that we have thought or experienced it before. — WILLIAM JAMES, *Psychology, Advanced Course*, Vol. I, p. 648

4. Sometimes ideas are described as imaginations. This term is used to indicate that a mere rearrangement of elements of memories has been made. . . . When the combinations which go on in consciousness are purely capricious, we speak of fanciful imaginations. When, on the other hand, recombinations of mental processes are worked out systematically and coherently, we speak of scientific imagination. — C. H. JUDD, *Psychology*, p. 255

5. In any case, whether the recognition is definite or indefinite the reproductive imagination with recognition is properly called memory. — KNIGHT DUNLAP, *Elements of Scientific Psychology*, p. 160

6. A memory implies sensimaginal resources more than sensational; the body at large is less involved, and the cortical part of the cerebrum more. The total image, which is usually the smallest unit of cognitive reference in memory and in imagination, is organized under central conditions; and the trains and sequences of images are also centrally controlled. — MADISON BENTLEY, *The Field of Psychology*, p. 252

TOPICAL OUTLINE

General Nature

- *A*. Rank among the mental functions
  - I. Complexity in composition, variety and range in function
    1. Conserves and extends the use of experience
    2. Gives to purpose means of seeing and attaining ends

II. Relation to sense experience
1. Both are reactions of conserved sense experience
2. Both lack detail and stability as conscious reactions
3. Both show degrees of emancipation from the limitations of "setting," of space, and of time

B. Uses of the term "image"

I. Physical: designates reflection of objects in a smooth surface

II. Physiological: refers to pictures formed on retina by optical parts of eye

III. Psychological: designates conscious reaction to discrete, focalized experience aroused by either external or internal stimulus
1. Imagery of perceptual reaction
   a. Reaction of perceptual pattern by external stimulus
      (1) True: corresponding to definite objects
      (2) False: noncorrespondence between perceptual reaction and its object — illusions
   b. After-images
      (1) Positive
      (2) Negative
   c. Images of perseveration: due to the gradual subsidence of sense experience
2. Imagery of ideational reaction (reinstated sense perception)
   a. The memory image: imagery corresponding to past concrete experience consciously identified
   b. The imaginative image: imagery reinstated but neither corresponding to nor identified as former experience
      (1) Controlled imaginative image
      (2) Uncontrolled imaginative image

Aspects of Forming Memory Reactions

A. Receiving and organizing sense impressions (a large phase of learning)

B. Retention (physiological basis of memory)

I. Forgetting as an indirect measure of the amount of retention

II. Causes of forgetting
1. Several kinds of inhibitions
2. Non-use of brain centers
3. Hereditary factors
4. Disease and ill health

C. Recall: conscious reinstatement of sense perception

I. Means of recall: cues, either sense perception or images, ideas, or emotional complexes

II. Laws of association functioning in recall

III. Kinds of recall
1. Empirical: the bonds of connection are formed without plan or purpose
2. Logical: based upon the fact that bonds of associations are formed according to plan and intention (subject matter consciously organized)

IV. Failure to recall
   1. Insufficient number of bonds of association
   2. Improper attitude, misdirected attention, unfavorable emotional setting

D. Recognition (recognizing consists in part reacting to an object or an idea in the same way that it was reacted to in sense experience)

I. Kinds of recognition
   1. Perceptual recognition
   2. Ideational recognition

II. Factors involved in recognition
   1. Kinæsthetic sensations aroused by responses similar in kind to those made in previous experience: familiar movements
   2. Associated mental elements involving time, space, and "setting"
   3. Feeling-tone of familiarity

III. Functions of recognition
   1. To produce definition and strength in responding
   2. To classify events, objects, and facts in specific ways

IV. False recognition (a partially old response without adequate recall)
   1. Influence of attitudes and prepossessions on recognition
   2. Influence of age on false recognition

Methods of Remembering

A. Proper attitude and intention at the time of learning

B. Comprehending and organizing subject matter

C. Proper control of the laws of inhibition and the laws of learning and methods of practice and use of memory

Imagination (consists in recombining Imagery in the Process of Recall)

A. Imaginative content
   I. Concrete or symbolic and verbal
   II. Abstract and embodying the meaning side of images

B. Function of imagination
   I. Controlled imagery in constructive and creative imagination
   II. Uncontrolled imagery as in complexes, suppressions, dreams, reveries

Comparison between Memory and Imaginative Imagery as to Familiarity, Definition and Color, Duration and Change

INTRODUCTION

Memory. The facts of retention and association are revealed through reproduction, recall, and recognition, — all different aspects of remembering.

Reproduction, as used here, refers to all those responses to sense experience that occur at the end of after-images and of primary memories (**38**: 399). The time limits or end of these

processes is not readily determined, but their presence may be practically eliminated at once by engaging in responses other than those involved in the sense impressions. This may be done by counting, saying the alphabet, or repeating poetry for ten or fifteen seconds. Then the response made to the stimulus at the close of the interpolated responses constitutes reproduction. It may be reckoned as a means for recovering sense experience in its original form before the subject has changed his "mind set" or before he has thrown off the experimental mood and set about other work.

With the lapse of time the exact form and pattern of our experience is decidedly changed, through the loss of details, by the rearrangement of the material and by the introduction of new material into the original pattern. The reinstatement of such experience in part or *in toto*, however much or little altered, is known as recall. When the process occurs under voluntary attention, guided by some purpose or end, it forms logical recall, but if it occurs merely according to the laws of association, without purpose and uncontrolled by any conscious principle, it becomes empirical recall; for example, grouping the presidents of the United States according to their native states or according to political parties is logical recall, whereas recalling them in the time order of service and as learned is empirical recall.

The conditions of recall are grounded on the physical integrity of the neurones and upon the strength of connections between neurones formed under the laws of association. The direct means for using the effects of these laws are found in cues — sense perceptions, images, and ideas — while the more remote aids consist of purposes, attitudes, moods, and sentiments (**29**: 366–368).

For experimental purposes the failure to recall may be assigned to one of two causes, forgetting and interference. An experience is forgotten when the cortical subsidence of the neural modification has gone beyond the possibility of normal reëxcitation. Although experimentation gives no evidence of the condition of the nerves in such a state, it does indicate the

presence and the rate at which the subsidence occurs, as may be seen in results similar to those upon which the laws of forgetting are based. Interference in recall arises from the nature and relative strengths of the bonds of association and from emotional effects produced either at the formation of the association or in the effort to recall. Concerning the former, the experiments given relate to three kinds: (1) retroactive (**29**: 382), (2) initial, and (3) effectual. They are usually described as inhibitions (**38**: 388). Emotional complexes and shocks as causes for preventing recall cannot be profitably studied in the laboratory. The more recent literature on the unconscious and psychoanalysis will introduce the student to this important and interesting subject (**3**: 260–262; **4**: 208–243).

Recognition marks the final phase in a full or completed memory; it is the means whereby a recalled object is identified as to circumstances or as to the time and the place where it was first encountered. An adult American of high-school education doubtless recalls the name of the king of England during the American Revolution, but the chances are that he no longer recognizes the name. The average American forgets the particular connections in which that bit of historical information was acquired and the name through frequent use has become an element of knowledge held in a system of general, rather than particular, relations (**42**: 270–279). To recognize George III as a name, a portion at least of the particular experiences incidental to learning it must be reëxcited as it is being recalled. Recognition is a learned response, and the art of recognition involves the use of the learned neural patterns just as they were used in the learning stage. The difference between recognition and recall memory consists in the fact that the former requires particular identification of the object in subsequent presentations, whereas the latter requires only a reinstatement of the object.

Images. The term "image," like the term "feeling," is used with several meanings but in the former term they are susceptible of fairly definite descriptions, about which there is general agreement. One of the earlier and common descriptions states that the images form a special class of conscious processes in distinc-

tion from sensations, perceptions, thoughts, emotions, volitions, and so on. This usage has come to mean a centrally excited mental process which forms the essential counterpart of earlier perceptions and is often described as the consciousness of an object or of a quality not present and felt not to be present to the senses. A second and more restricted use of the term occurs in its designation of "memory images." Here it signifies discrete portions of past experience having a particular, personal, and familiar character. Pillsbury considers the memory image as a present consciousness of an old experience, with the knowledge that it is old (**29**: 255–258). Again, as a third meaning, it signifies those alterations of the memory image that destroy correspondence with previous experience and give to it a novel character. Such processes are termed imaginative images. They may refer to the past, the present, or the future, but never to experience as it actually occurred. Finally, the term is used to designate all those conscious processes that persist even after the stimulus has been removed. They are termed after-images and sometimes primary memory. Closely allied to the imagery of primary memory are the images of the so-called "perseverative tendency." One may be quite susceptible of the kinæsthetic imagery of this class; for example, while sitting in a chair after having ridden on a train for several hours there may suddenly appear a consciousness of the train motion. We are here concerned with the centrally aroused images embraced by the first three uses and shall consider their nature and kind and the distinctions between memory imagery and imaginative imagery.

Nature. The nature of a centrally aroused image involves a number of variable characteristics, the more evident of which are vividness, stability, completeness, and plasticity (having three dimensions). The manner of appearing (whether spontaneous or with effort), although not part of the nature of an image, is an additional aspect. It has been shown that these characteristics do not necessarily vary together. An image may be incomplete but vivid, or it may be flitting but unusually vivid. Thus the image of a certain college building for me is incomplete and flitting, but the portions left are vivid. The

meaning of these aspects appears only as one tries to arouse imagery of the several sense modes and introspect it with care. Thus the attempt to image a brilliant sunset, the breakfast table as first suggested by Sir Francis Galton, the sound of squeaking mice or of rolling thunder, the touch of velvet or of sandpaper, brings the several attributes of imagery into more or less prominence.

Types of imagery. The number of different kinds of perceptions of an object that one may experience equals the number of disparate sensations that the object may arouse (2: 165–166). Two principles, at least, serve to reduce the actual number of perceptions considerably below the possible number: (1) the purposes of life seldom require that an object excite all the sensations of which it is capable (for example, it may suffice that one receive only visual impressions from a fruit-stand, although several others are possible); (2) only a portion of the sense impressions aroused may enter into the perceptual processes, the rest, for several reasons, not being utilized and on that account becoming ineffectual. The principles that operate in limiting the sensation qualities in perceptions extend necessarily to images, giving rise to the dominance of one kind of imagery, — a kind formed at the partial or total exclusion of others. Minds showing a preference for a particular kind of imagery are classified accordingly. These classes are visual, auditory, motor-tactual, gustatory, and thermal. Minds showing an equal preference for the first three types are classified as mixed types, which investigation proves to be by far the most prevalent class. In fact, a pure imaginal type having only one kind of imagery has yet to be found.

The images thus far considered are partial copies of the perceptual processes and, as such, are termed copy images, or object images. In addition to these, there is formed, especially among the educated, a system of symbolic images or word images, through the constant use of oral and written characters representing the facts of science and of letters. The more usual form is the word image, which may appear as visual, auditory, motor, or mixed type.

Memory and imaginative powers. The differences between these two sorts of imagery are evident when viewed from the standpoint of their function (**18**: 240–243). Pillsbury observes that the memory image is always true but old, and the imaginative is false and new in reference to actual experience. The differences in their nature, however, are not so striking as one might infer considering their common origin and that they are found to be difficult of demonstration. But the fact that they perform separate functions and have a different reference furnishes grounds for presuming that they differ in some respects. The functions of imagery in thought, action, and feeling are doubtless wider and of more consequence than current writers would seem to allow. A clear-cut purpose is aided by vivid imagery of ends and consequences; designs, patterns, mechanisms of machinery, are pictured before they are constructed. Theories, hypotheses, and complex forms of social relations are indebted to vivid, stable, yet pliable imagery.

EXPERIMENT 88. To make a Comparative Study of Reproduction, Recall, and Recognition of Common Objects, of Objects being used, and of Images of Objects aroused by their Names

NOTE. Although this experiment is exacting in critical observation and in the consumption of time, the insight given to the major problems of memory justifies its performance.

Material. Two groups of twelve common objects each (for example, thimble, eraser, gimlet, etc.); twelve names of common objects printed in large type on cardboard 4 in. by 12 in.; table at least 24 in. by 36 in.; black muslin for screen; stop watch or metronome; blank strips of paper, 2 in. by 8 in., for records.

Procedure. Group 1. Common objects. a. The objects are placed without order on the table and covered with muslin. At a signal "Ready" the cover is removed for nine seconds and the class observes the objects. After the ninth second the objects are again screened and every subject counts aloud for twelve seconds, when, at the command "Write," he records the names of the objects. As soon as he finishes, the record slip is turned over and indorsed with his name, the date, the kind of stimulus (in this instance "common objects"), and the nature of the response (in this case "reproduction"). The instructor takes charge of the records.

b. At the next class period S is required to recall and write on the record slips the names of the objects previously learned. S is granted sufficient time in which to make recall but is instructed to work briskly. The record slips are now properly indorsed and collected by the instructor.

c. The instructor dictates to the class the names of the objects, interspersing, without comment, four new names of objects that have been added to Group 1, and then exposes the objects arranged on the table as in the first presentation. S observes the objects critically and writes "R" after the names of those that are recognized and "X" after those not recognized. S is instructed to assure himself that each perceived object is *recognized* (identified as one previously observed). The objects are again covered and S writes after each "R" the aids to recognition. The aids are variable, of course, and some appear to be beyond conscious detection. The record slips are now properly indorsed with name, date, stimulus, and response, and are collected.

Group 2. Objects and their uses. a. At the next class hour or laboratory period following the last work on Group 1, the instructor arranges the objects behind a screen on the table. At a signal "Ready," having explained to the class the manner of presenting the objects, the instructor holds an object before the class and makes with it mimetic movements of its common use; for example, a hand lens is looked through, a pen makes writing movements, etc. Picking up, mimicking, and laying down the object should not consume, on the average, more than three seconds. After the exposure of the last object S counts aloud for twelve seconds, and at the command "Write" reproduces the names of the objects. The record slips are now properly indorsed, and are collected.

b. The same time interval between parts *a* and *b* of Group 2 is observed as between similar work of Group 1. The record slips having been distributed, S is told to write the names of the objects whose uses were mimicked. S works briskly in making the recall. The record slips are now duly indorsed, and are collected.

c. The instructor dictates to the class the names of the objects, interspersing, without comment, the names of a few objects that have been added to Group 2. The objects are then exposed, one at a time, without mimetic movements, and as they are exposed, S writes "R" after the names of those objects recognized and "X" after those that are unrecognized. Each subject, as far as possible, records the means of recognition in each instance. After the proper indorsements the instructor collects the records.

Group 3. Names of common objects. a. The same time interval that elapsed between the first exposures of the two groups of objects should be kept between Group 2 and Group 3 (common names). At a signal "Ready" the instructor says, "Image[1] a ——," at the same time holding up a card bearing the word whose image the subjects are to make, but not pronouncing it, and pausing two seconds with the card in view. The entire process for each card should not exceed five seconds. As soon as the last object is imaged, S counts as formerly, and at the command "Write" he records the names of the objects imaged. The record slips are indorsed according to conditions, and are collected. Questions are asked as to methods of reproduction.

b. The time interval before recall in this case should be similar to the same intervals of Groups 1 and 2. The record slips having been distributed, S records on them the names of the common objects previously imaged. Energetic work is required. The records are duly indorsed, and are collected. S tells aids and methods used in recall.

c. Record slips are supplied the class. The instructor dictates the names of the imaged objects and adds four new names, without comment. S now goes over the list and writes "R" opposite the name of each object whose image is recognized as similar to the one formed of the object when its name was presented on the card and writes "X" opposite the name of each object whose image is not recognized as having been formerly "imaged." The record slips are indorsed, and are collected as usual.

Results. Two or three members of the class now take charge of the nine classes of records. The teacher solicits from the class a further detailed account of reproduction, recall, and recognition of perceptions, perception-association (in this instance the object is associated with its use), and images, respectively. Arrange the results under two headings: "Subject's Report" and "Class Discussions."

Table XXXVII, on page 248, shows the chief quantitative relations between reproduction, recall, and recognition, respectively.

A class table consisting of average results should be worked out at the board and copied. Study Table XXXVIII, on page 249, with a view to answering the questions given under *Discussion of results.* Interpret the results of your class after they are tabulated, as well as your own, noting individual differences.

[1] If the term "image" is not understood by some, use "imagine" or "think of."

TABLE XXXVII. COMPARISON OF REPRODUCTION, RECALL, AND RECOGNITION

STIMULI AND NATURE OF REACTION	GROUP 1: OBJECTS		GROUP 2: OBJECTS AND USES		GROUP 3: IMAGES FROM NAMES	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
Given						
Reproduced						
Recalled						
Recognized						

Discussion of results. Why is it necessary to interpolate some kind of action between the exposure of the stimulus and the required memory response? Why are the memory responses to objects associated with their uses higher than similar responses to objects or to images? (Reproduction, recall, and recognition taken together or separately are termed memory responses.) Why is recall uniformly lower than reproduction and recognition? What is the difference between the recognition of an object and the recognition of an image or an idea? Do you have repeated dreams? How do you know? What do you discover as aids to recognition? Do you observe in yourself or others kinæstheses serving as an aid? Give instances. Show by an example, either from your own experience or from the literature, that it is possible to recall without recognizing the image. Show similarly that it is possible to recognize objects and images without the responses of recall (false memories, memory illusions). Give examples of such from your knowledge or experience.

Suggest some ways for improvement of recall based on the results of this experiment. Is it possible to improve recognition? Justify your answer. What phase of memory is most susceptible of improvement?

Why is a principle in mathematics better remembered after one has solved many problems by means of it? If you can discover any bearing of attention upon recall in this experiment, point it out and see if you can derive a principle. What effect has familiarity of an object upon reproduction and recall? Give example. Give examples illustrating the difference in recall of reactions due to direct observation (direct perception) and in recall of implicit reactions (imaged objects) aroused by suggestions or by oral or written language. Is memorizing doing physical work? Explain your answer.

READINGS. **2**: 169, 187–192; **9**: 132–134; **29**: 388–397; **38**: 407–413; **41**: 87–90; **46**: 368–375.

TABLE XXXVIII. COMPARING REPRODUCTION, RECALL, AND RECOGNITION (CLASS RESULTS)

	Stimuli	Objects					Object — Use					Images					Grand Total		
		Sub-jects	Responses Total	Responses Aver-age	Mode*	Per Cent	Sub-jects	Responses Total	Responses Aver-age	Mode*	Per Cent	Sub-jects	Responses Total	Responses Aver-age	Mode*	Per Cent	Responses Total	Responses Aver-age	Per Cent
Reproduction	16	77	817	10.6	11^{24}	66	74	958	13	13^{22}	81	77	803	10.4	11^{12}	60	2578	11.3	70.6
	False reproduction .	36					2					10					48		
	Highest . .	14^{4}					16^{1}					15^{1}					16^{1}		
	Lowest . .	7^{3}					9^{2}					4^{1}					7^{1}		
Recall	16	71	508	7	7^{16}	44.7	72	611	8.5	9	52	70	122	1.7	1^{12}	10.8	1241	5.7	36.4
	False recall .	47					30					53					130		30.6
	Highest . .	13^{1}					13^{3}					7^{1}					13		
	Lowest . .	3^{1}					4^{2}					0^{26}					0		
Recognition	16	71	887	12.5	11^{18}	78	72	1026	14	15^{21}	89	70	764	10.9	12^{12}	68	2677	12.5	81.4
	Highest . .	16^{3}					16^{17}					15^{2}					16		
	Lowest . .	4^{1}					8^{1}					2^{2}					2		
	Grand total		2212	10		63		2595	12		76		1689			46			

* The exponents show the size of the mode.

Experiment 89. To study the Effect of Intention on Recall (Two Students)

Material. Two stanzas of six or eight lines taken from the same poem (the stanzas given here will answer, provided that they are not read before the experiment); cover cardboard 4 in. by 6 in.

Stanza A

Through twilight shades of good and ill
Ye now are panting up life's hill,
And more than common strength and skill
Must ye display;
If ye would give the better will
Its lawful sway.

Stanza B

Let no mean hope your souls enslave;
Be independent, generous, brave;
Your Father such example gave,
And such revere;
But be admonished by his grave,
And think, and fear!

Procedure. 1. *Learning period.* E places Stanza B, covered by cardboard, on a table in front of S. E gives special instructions as to how the learning is to be done: (1) Use the *whole method* in learning each stanza (that is, read the entire stanza to the end without repeating any part); it is then covered again with cardboard and, after a pause of ten seconds, is reëxposed and read through a second time. The trials are repeated until S can repeat the stanza unaided by the text. A record is made of the number of trials. (2) Stanza B is to be learned for the mere purpose of reciting it to E, and S must not attempt to do this until he is sure of succeeding; all necessity for retaining it ceases with the first complete recitation.

Stanza A is now placed on the table and covered. S is told that the stanza is to be learned primarily for retaining it as a memory gem and only incidentally for reciting it to E. Otherwise observe the same method as in Stanza B. S recites the stanza to E as soon as learned and E records the number of trials.

2. *Test period.* At the next class period S is asked to recite Stanza B. If an error occurs, the stanza is exposed and read through once, as in the learning period; if one trial does not suffice, another and another are made until the stanza is fully relearned. The number of trials for relearning is recorded. Stanza A is now recited, and if

errors occur, relearning trials are made as with Stanza B until it can be recited without error.

Results. E may apply the *saving method*, as used in measuring the rate of forgetting, to determine the effect of intention. If Stanza B required eight readings in the learning period and three in the test period, the amount retained is assumed to be $\frac{8}{8}-\frac{3}{8}$, or 62 per cent; and if Stanza A required nine readings for complete learning and four for relearning, the amount retained is $\frac{9}{9}-\frac{4}{9}$, or 55 per cent; thus tending to show that the intention to learn the stanza permanently operated as an inhibition. Of course a direct comparison of the number of trials in relearning tends to show the same thing.

Discussion of results. What difference, if any, did the intention make in memorizing Stanza A? Did it produce an inhibition or cause you to make a greater effort? If you are still able to repeat both stanzas, which one requires less effort? Are your results similar to those of other members of the class? Why does one remember so little of his newspaper reading? State the effect of intention on recall according to your own results. Devise and perform another experiment to demonstrate the same law.

Inference. State the effect of intention on the amount of recall in your case.

READINGS. **26**: 165–166; **27**: 102–104; **29**: 366, 372–375; **39**: 285–297; **41**: 92–94; **44**: 75–83.

EXPERIMENT 90. To study Recognition (Two Students)

NOTE. This exercise has been adapted from Dunlap's "Omitted Letter Test."

Material. Stop watch; two lists of ten words each.

Each word should contain from eight to ten letters and be typewritten correctly on one side of a visiting card. On the other side the letters of the same word should be typewritten out of order and with one letter omitted; thus: first side, "promoted"; reverse side, "otmeprd." The following words will serve as samples:

FIRST SIDE	REVERSE SIDE	FIRST SIDE	REVERSE SIDE
Periphery	Rieyhepr	Sardonic	Nicoadr
Hypnotic	Nothipc	Marginal	Garlman
Unwonted	Downuet	Sociable	Losibec
Improper	Pompire	Decisive	Sevicei
Vaporous	Uvosrop	Pathetic	Ithacep

Procedure. E is provided with a set of ten cards containing the words typewritten in the manner described. E first shows S the word spelled correctly and requires him to pronounce it distinctly; then E reverses the card and at the same time starts the stop watch, and S tries to find the missing letter. As soon as S detects the missing letter, he writes it on paper (if other students are not present S may name the missing letter orally). The watch is stopped as soon as S writes the letter. If S does not find the missing letter in one minute, the card is laid aside and E presents the correct word of the second card, S pronounces it, and then the misspelled word is presented. If S fails to identify the missing letter in one minute, the card is put aside and the third word presented, and so on until the ten words have been shown. E now shows the cards with the unidentified letters a second time, first showing the correct word and then the incorrect, keeping the time as before. The cards are presented in the same time order, and if S fails to identify the missing letter in one minute, the card is put aside, and E continues with the next card, and so on until these cards have all been shown a second time. If any of the letters were unidentified in the second trial, a third is given, and so on until the ten missing letters have been correctly responded to. E and S now exchange places and proceed similarly with the second list.

Results. Subject's report. Tell how the correct word was retained while you were looking at the misspelled word and the methods used in discovering the missing letter.

Experimenter's report. The following headings may be used:

Trial	Time	Correct Word	Misspelled Word	Omitted Letter	Remarks

Discussion of results. Why was the recognition ideational? What distinctions may be made between ideational and perceptual recognition? Why did you keep rehearsing the correct word? Did you use memory or imagination in finding the letter? When the absent letter was recognized did it appear alone or in its proper place in the word? Did you at times doubt the correctness of the recognized letter? In such cases were the words familiar or strange? Is there any evidence showing that practice aided recognition? Does recognizing consist in perceiving an idea or an object in a recalled or observed situation that is specific.

Inference. Give a definition of recognition.

Readings. **2**: 188–192; **29**: 387–397; **32**: 248–250; **38**: 407–413; **41**: 106–107.

EXPERIMENT 91. To study Methods of Memorizing: the Whole Method and the Part Method

Material. Six stanzas of "Three Years she grew in Sun and Shower"; a sonnet from Wordsworth, and one from Keats.

THREE YEARS SHE GREW IN SUN AND SHOWER

Three years she grew in sun and shower,
Then Nature said, "A lovelier flower
  On earth was never sown;
This child I to myself will take;
She shall be mine, and I will make
  A lady of my own.

"Myself will to my darling be
Both law and impulse: and with me
  The girl, in rock and plain,
In earth and heaven, in glade and bower,
Shall feel an overseeing power
  To kindle or restrain.

"She shall be sportive as the fawn
That wild with glee across the lawn
  Or up the mountain springs;
And hers shall be the breathing balm,
And hers the silence and the calm
  Of mute insensate things.

"The floating clouds their state shall lend
To her; for her the willow bend
  Nor shall she fail to see
Even in the motions of the storm
Grace that shall mould the maiden's form
  By silent sympathy.

"The stars of midnight shall be dear
To her; and she shall lean her ear
  In many a secret place
Where rivulets dance their wayward round,
And beauty born of murmuring sound
  Shall pass into her face.

"And vital feelings of delight
Shall rear her form to stately height,
  Her virgin bosom swell;
Such thoughts to Lucy I will give
While she and I together live
  Here in this happy dell."

SONNET BY KEATS

The poetry of earth is never dead:
When all the birds are faint with the hot sun,
And hide in cooling trees, a voice will run
From hedge to hedge about the new-mown mead;
That is the Grasshopper's — he takes the lead
In summer luxury, — he has never done
With his delights; for when tired out with fun
He rests at ease beneath some pleasant weed.
The poetry of earth is ceasing never:
On a lone winter evening, when the frost
Has wrought a silence, from the stove there shrills
The Cricket's song, in warmth increasing ever,
And seems to one in drowsiness half lost,
The Grasshopper's among some grassy hills.

SONNET BY WORDSWORTH

Earth has not anything to show more fair:
Dull would he be of soul who could pass by
A sight so touching in its majesty:
This City now doth, like a garment, wear
The beauty of the morning; silent, bare,
Ships, towers, domes, theatres, and temples lie
Open unto the fields, and to the sky;
All bright and glittering in the smokeless air.
Never did sun more beautifully steep
In his first splendour, valley, rock, or hill;
Ne'er saw I, never felt, a calm so deep!
The river glideth at his own sweet will:
Dear God! the very houses seem asleep
And all that mighty heart is lying still!

Procedure. Each student is to learn a section by wholes and one by parts. The students work in pairs: S learns the first three stanzas of the poem by wholes and the last three by parts, the stanzas forming the parts; E learns the first sonnet by wholes and the second sonnet by parts, the first part of the sonnet being the first four lines, the second and third parts having five lines each. This allows S and E about the same number of words. The instructor allows twelve minutes for each memorization by wholes, keeping the time and giving directions to begin and to stop. He allows four minutes for each of the sections.

S is directed to make as many repetitions as he chooses in the time allotted. He may vocalize, but it must be done in the lowest tone

possible. He may, in part of the repetitions, recite to himself, looking at the material when necessary. While studying the sections, he must have only the part being studied exposed. Two small pieces of cardboard may be used to cover up the sections not being studied. The instructor may prefer to prepare his own material and hand it out as needed. S makes a signal to E at each repetition and E keeps a record of repetitions in all cases.

The order of experimenting should be as follows: (1) S learns the first three stanzas by wholes, spending twelve minutes; (2) S rests for three minutes, with the direction that he is not to think about the poem; (3) S recites to E in writing (when he goes wrong, E corrects him, and when he hesitates five seconds, E prompts him, recording the full time, by means of a clock or stop watch, and the number of promptings and corrections on the recitation sheets); (4) E learns by wholes the last three stanzas; (5) E waits three minutes; (6) E recites; (7) S learns by parts the first sonnet; (8) S waits three minutes; (9) S recites; (10) E learns by parts the second sonnet; (11) E waits three minutes; (12) E recites. It will probably be necessary to postpone the part learning to the next laboratory period.

Results. Each student will have three results for both whole-time and part-time memorizing: the time record, the number of errors, and the number of promptings. Value each error as half a prompting, add to the promptings, and consider the promptings as indicating relatively the amount of learning. Each student, comparing results by wholes and parts, should answer from his own records which method is better for him.

Class results should be placed on the board, and the average time and the average number of promptings should be compared and a standard result obtained for the class.

Discussion of results. When might learning by wholes prove uneconomical? Give examples (1) of your own use of one or both methods; (2) where a combination of the two procedures may be used.

Inference. Give a statement as to the comparative value of the two methods.

READINGS. **1**: 7–77; **9**: 159–162; **17**: 289–292; **26**: 233–235, 335; **41**: 92–94.

EXPERIMENT 92. To study Retroactive and Anteactive Inhibition (Two Students)

Material. Two series, 1 *a* and 2 *a*, of fourteen nonsense syllables each, typewritten on adding-machine paper 8 cm. wide with 3 cm. between successive words; two series, 1 *b* and 2 *b*, of twelve foreign

words each, from some language unfamiliar to the class, typewritten on strips of paper in the manner of the syllables; small tachistoscope (see Fig. 17); metronome.

Procedure. 1. E exposes nonsense syllables of Series 1 *a* for two[1] seconds at a time and allows three seconds to intervene between exposures, using the small tachistoscope. Greater accuracy will be secured if he counts, with the metronome, "one," "two," "three," and at the end of the third count thinks "expose" instead of counting "four," and exposes the word, beginning over at the sixth beat "one," "two," "three," etc. The exposures are repeated until S can recite the series aloud to E, the number of repetitions being recorded.

S now relaxes for ten minutes in any way most agreeable to him (for example, reading humorous matter or looking at pleasing pictures). Series 1 *b*, foreign words, is then presented at the same rate as Series 1 *a* until it is learned. S recites to E. Care should be taken not to overlearn either series.

At the next laboratory period S relearns Series 1 *a*, adhering to former conditions. E notes the number of times the series is exposed for complete learning.

2. At the next laboratory period E presents Series 2 *a* in the same manner as 1 *a*. S recites the syllables to E as soon as they are learned. E begins at once to expose Series 2 *b*, foreign words, without allowing S any relaxation whatever between learning the syllables and the words. S recites the words to E as soon as learned. Before relearning Series 2 *a* allow the same time interval to elapse as before relearning Series 1 *a*.

The entire experiment, both part 1 and part 2, should be repeated at least once with new syllables and words. It is important that, as far as possible, the instructor conduct this experiment so as to keep the students ignorant of its purpose.

Results. *Experimenter's report.* Give results in tabular form.

A table is given here showing the results of two subjects who performed the experiment once. The entire experiment consumed four days.

The percentage of syllables forgotten when an interval occurred for these subjects is 23.6, obtained from the following operation:

$$\frac{2.25 \text{ (number of repetitions in relearning)} \times 100}{9.5 \text{ (number of repetitions in learning)}} = 23.6 \text{ per cent,}$$

whereas the percentage forgotten without an interval is 51.5 per cent.

[1] If the exposure is actuated by a mechanical device, one second is sufficient.

TABLE XXXIX. EFFECTS OF RETROACTIVE AND ANTEACTIVE INHIBITION ON MEMORY

DAY	SYLLABLES				FOREIGN WORDS		AVERAGE FOR SYLLABLES	AVERAGE FOR FOREIGN WORDS
	Repetitions in Learning		Repetitions in Relearning		Repetitions in Learning			
	Subject 1	*Subject 2*	*Subject 1*	*Subject 2*	*Subject 1*	*Subject 2*		
1	10.0 (1*a*)	9.0			7.0	6.0	9.5	6.5
2			2.5 (1*a*)	2.0			2.25	
3	8.5 (2*a*)	8.0			11.0	8.5	8.25	9.75
4			4.5 (2*a*)	4.0			4.25	

Discussion of results. Compare the number of repetitions in relearning Series 1 *a* with number in relearning Series 2 *a*. What different condition in part 2 might affect memory for Series 2 *a* when recalled? Show from this the meaning of retroactive inhibition.

Compare the number of repetitions in learning Series 1 *b* and Series 2 *b*. What condition in part 2 might affect the learning in Series 2 *b* that is not present in Series 1 *b*? From this explain anteactive inhibition.

The student should compare his results with those found in the table. Are any results of practice shown? Explain. Can you explain why the second group of foreign words took longer than the first group? Is there any reason why there was less improvement in relearning Series 2 *a* than in relearning Series 2 *b*?

Inference. Formulate this law of inhibition.

READINGS. **29**: 382; **34**: 1–59; **38**: 387–388; **40**: 47–50; **41**: 101.

EXPERIMENT 93. To study Associative Inhibition

A. Meaningful Words: Books and their Authors.

Material. A list of twelve well-known books with their authors (as *Paradise Lost*, Milton); a list of twelve well-known books, different from those in the first list, with false authors, using the same twelve authors as in the first list (as *Vanity Fair*, Milton); chronoscope.

Procedure. E first reads the list of works to see if S knows the authors. If unfamiliar ones are found, E substitutes for them works and authors well known to S. E now makes a determination with the chronoscope (preferably Sanford's chronoscope) of S's reaction time to the list, S responding with the author when the work is given. E hands to S the second list, consisting of the familiar authors and

false works, and S proceeds to memorize them in any way most natural to him. He must obtain a complete mastery of the material, and must not report to E until he is certain that he has formed such a strong association bond between the author and the false work that he can recite to himself the entire list in order or with the items interchanged. When S is ready, E takes his reaction time to the false works and authors with the same procedure as in the first list, except that the order is not the same. This finishes part *A*. Part *B* is not begun until the next period.

Results. *Subject's report.* S reports any inhibitions. He compares the reaction times for each author in the first list and in the second list for the purpose of finding whether any difference in time can be accounted for by a difference in his familiarity with the original author and work.

Experimenter's report. Tabulate results in the following form:

TABLE XL. COMPARISON OF REACTION TIMES FOR LISTS OF WELL-KNOWN AUTHORS WITH REAL WORKS AND WITH FALSE WORKS

AUTHOR'S NAME	REACTION TIME FOR REAL WORK	REACTION TIME FOR FALSE WORK
1		
2		
3		
.		
.		
.		
12		

Discussion of results. If there is a uniformity of difference in reaction time, which is greater the reaction time of the true works and the authors or that of the false works? If there is no uniformity, study each case, or similar cases, and account, if possible, for the difference, taking into consideration possible interference. If there are degrees of familiarity, did you find most interference in cases where the work was best known (strongest bond of association), or least known, or in an intermediate case, if such apparently exists?

B. Meaningless Words: Nonsense Syllables.

Material. In order to study the principle of associative bonds more fully, with more controllable material, we use nonsense syllables in three series. Series I, II, and III each consists of two sets of pairs of syllables, the first members of which are the same in both sets; that

is, in the series twelve syllables are paired (1) with twelve for learning, and (2) with twelve different ones for *testing*. A tachistoscope and a chronoscope are needed.

Procedure. Series I is the well-known series. E exposes the pairs of the learning set in the tachistoscope at a regular rate and continues the process until S can recite the pairs to him perfectly, forward and backward, forming *strong* associative bonds. The second set, the *test* set, is learned to such a degree that S can recite it forward. The second sets of the two remaining series and the first set of Series II are also learned so that they can be recited forward, forming *medium* associative bonds. The first part, the learning set, of Series III is learned slightly so that the subject is able to anticipate the associate when the antecedent of the pair is presented. When the learning is finished in each series, reaction times are taken by having S respond with the second syllable of a pair when E presents the first. This method gives a means of comparing with a standard (medium learning) a series thoroughly learned, one learned to a medium extent, and one slightly learned. Since the antecedents are the same in the two pairs of the same series, this furnishes a measure of the amount of inhibition aroused by previous associations with a syllable when the associative bonds are *strong*, *medium*, and *weak*, respectively. As the control of the degree of learning the different sets of the several series is obviously essential to the success of the experiment, the number of repetitions required to thoroughly master Set 1 (learning set) of Series I may well be used as an index to the probable number of repetitions required for sets to be less thoroughly learned. An arbitrary number of repetitions for the different degrees of mastery cannot be assigned, owing to individual differences in learning by rote. As a precaution it is suggested that the test sets throughout be repeated half the number of times of Set 1 of Series I before S tries to recite the set forward, and that Set 1 of Series III be repeated one fourth or one third as many times before reciting.

Results. It is desirable that the facts of this experiment be kept as objective as possible, and for that reason the subject's report is not taken.

Experimenter's report. Tabulate results as in Table XLI.

The table shows the number of repetitions necessary in each kind of learning, the associative reaction time for each of the seventy-two pairs, and the inhibition caused in Set 2 by the new association. This is found by subtracting the reaction times of Set 2 from those of Set 1 and may be either plus or minus.

Where is the greatest inhibition found?

TABLE XLI. REACTION TIME IN ASSOCIATIVE INHIBITION IN LEARNING PAIRED ASSOCIATES

NUMBER OF PAIR PER SET	SERIES I			SERIES II			SERIES III		
	Number of Repetitions			Number of Repetitions			Number of Repetitions		
	Set 1, Complete Learning	*Set 2, Test, Medium Learning*	*Difference + or −*	*Set 1, Medium Learning*	*Set 2, Test, Medium Learning*	*Difference + or −*	*Set 1, Slight Learning*	*Set 2, Test, Medium Learning*	*Difference + or −*
1									
2									
3									
.									
.									
.									
12									
Average reaction time									

A class table should be made, showing, opposite each student's name, the number of repetitions necessary to learn the well-known series and the average amount of inhibition in each of the three series. This table should be studied (1) to show individual differences in rote memory; (2) to show individual differences in inhibition; (3) to obtain a standard for the class in both cases.

Discussion of results. Show how the results correspond with Müller and Schumann's law of associative inhibition. Are there exceptions? Explain them. Explain, from studying your results, the truth of Pope's familiar line, "A little learning is a dangerous thing." Give three common examples of associative inhibition.

Inference. In a short statement give as inference the truths illustrated above concerning the law of associative inhibition, and then state the law.

READINGS. **20**: 297–299; **29**: 379–380; **38**: 388–389.

EXPERIMENT 94. **To study the Memory Span (Class Experiment)**

Material. 1. *Digits.* Four series of twelve each:

1. 457264829565
2. 659748379842
3. 932547876453
4. 865934763291

2. *Words.* Four series of twelve each (disintegrated syllables):

tap	top	bet	tun
day	nor	tan	not
box	lap	bun	tar
sap	car	run	met
man	par	not	boy
jot	pot	run	got
pew	mar	met	cow
nap	sir	can	hat
ban	rot	see	dog
pit	tow	the	mat
vow	pat	wet	ran
tub	fin	tot	cat

3. *Integrated syllables.* *a.* Concrete sentence (sixty-four syllables):

Rain on the roof, softly, continuously, falling, like an old clock ticking, ticking always; rain on the street, gray lines between earth and heaven, men and women threading the line mazes, the trees breaking the lines here and there; rain, promise unfailing of new life.

b. Abstract sentence (sixty-four syllables):

But indifference will not guide nations to the perfect city of God. Undeluded popular consent is indispensable and will be impossible until the statesmen can appeal to the people's vital instincts in terms of a common religion.

4. *Ideas.* *a.* Concrete sentence (seventy-six words):

But he who has been earnest | in the love of knowledge | and true wisdom | and has been trained | to think | that these are the immortal | and divine things | of a man, | if he attain truth, | must of necessity | as far as human nature is capable | of attaining immortality, | be all immortal; | as he is ever serving | the divine power; | and having the genius residing in him | in the most perfect order, | he must be preëminently happy. |

b. Abstract sentence (sixty-eight words):

That, therefore | which giveth truth | to what is known, | and dispenseth the power | to him who knows, | you may call the idea of good | being the cause of knowledge | and of truth, | as being known by intelligence. | And as both of these two, | knowledge and truth, | are so beautiful, | when you deem | that the good is something different, | and still more beautiful | than these, | you shall deem aright. |

Procedure. The instructor distributes slips of paper of uniform size, and the students are instructed in the audito-voco method. In this method, as the subject hears each unit of material read, he repeats it aloud. This method is used for all material except the ideas,

which are written by the subjects after hearing the paragraph read once. In all cases, at the end of the presentation of a series, the instructor says "Count" and the subjects, together with the instructor, count ten, beginning, at a signal from him at the end, to reproduce the material on the slips. Since the metronome is a distraction and great care should be taken to avoid sources of distraction, some other timer may be used, as a clock with second hand or a large pendulum. The instructor should keep the time uniform, giving about half a second to each unit, except the ideas. As much time as desired is given for recall. When the students have their recalls completed, the instructor writes the material on the board, and the students check the number recalled correctly. The span in each case is the best record made in a series.

Results. *Subject's report.* Give inhibitions, etc.

Experimenter's report. The results may be given as in Table XLII. Every omission is scored as one error; every displacement by one or two places is scored as half an error, a displacement by three or more places as one error. The errors are subtracted from the number correct.

The class results may be worked out in an array, and the median, mode, and average found.

Discussion of results. Why was counting interpolated before the reproduction? Give definition of memory span for digits. How does the memory span differ from the span of attention? Compare the span found here with that given in standard texts. Considering the spans of the group, what do you conclude as to individual differences in memory span? Does memory span improve with practice? How does memory span differ with different materials? Give some factors (in your own case) which affect the memory span. Is there any correlation between memory span and intelligence score? What aids to memory were noted? Give practical examples of conditions involving memory span.

Inference. State (1) the number of discrete objects in the memory span, (2) effect of kind of material on span.

READINGS. **6**: 229–258; **16**: 393–403; **26**: 141–146; **41**: 139–142; **45**: 150–201.

EXPERIMENT 95. To study Individual Differences in Free and Active Imagination

Material. Five numbered cards containing ink blots. These may be made of a convenient size to use in a class experiment by dropping ink with a pipette on a sheet of absorbent paper, folding it through the center and mounting on cardboard.

TABLE XLII. MEMORY SPAN

I. DIGITS

SERIES	NUMBER SHOWN	NUMBER RECORDED	SCORE
1			
2			
3			
4			

II. DISCRETE SYLLABLES

SERIES	NUMBER SHOWN	NUMBER RECORDED	SCORE
1			
2			
3			
4			

III. SYLLABLES IN SENTENCES

	NUMBER GIVEN	NUMBER RECORDED	SCORE
1. Concrete			
2. Abstract			

IV. IDEAS

	NUMBER GIVEN	NUMBER RECORDED	SCORE
1. Concrete			
2. Abstract			

Procedure. Students are arranged in amphitheater style. They are told that an ink blot is to be shown for three minutes and that during that time they are actively to use the imagination and to write down, on blanks numbered to correspond to the blot numbers, the pictures they can see in the blots, just as they have made objects out of cloud formations. The instructor gives the signal to start and, after three minutes, the signal to stop, and the students write down lists as directed.

Results. The students go to the blackboard and write their lists for the five blots, writing at the end the number of objects in all. The time it takes to imagine one object is found by dividing the total time, 900 seconds, by the number of objects. The individual rates are compared and the median and average found. The highest and the lowest rate are noted. Several students are detailed to note

the objects that are common and the times they are repeated, also the number of different objects.

A frequency table is here given, showing the number of objects found in the five blots by thirty-two persons in the five three-minute periods. A similar one should be worked out by the class as the experimental work is completed.

TABLE XLIII. FREQUENCIES FOR TOTAL NUMBER OF OBJECTS IN FREE IMAGINATION IN NINE HUNDRED SECONDS

NUMBER OF STUDENTS	TOTAL NUMBER OF OBJECTS	NUMBER OF STUDENTS	TOTAL NUMBER OF OBJECTS
2	21	2	46
3	26	2	47
2	28	1	48
1	30	1	49
1	31	2	50
1	34	1	51
2	36	2	54
1	37	1	59
1	38	1	66
1	43	1	67
1	44	1	69
1	45		

The frequency table is arranged in an array. The scores (in this case the number of objects perceived in the five blots) are written in a column, and opposite each score is written its frequency (the number of times it occurs). In this table the step is one unit; often it is convenient to group by more than one.

Classify the objects you mentioned as to origin, — as due to heredity, education, occupation, or some special environment, and tell which class appeared most frequently.

What evidence do you find in your imaginal responses of visual, auditory, or motor ideas? Is there any indication of a dominant type?

Discussion of results. These questions should suggest the general trend of discussion. The discussion of the table in class should bring out clearly individual differences in the amount of imagination, and reference to the list should be stressed as indicating the kind or type.

Inference. Show how free imagination reveals individuality.

READINGS. **2**: 162–170; **5**: 137–204; **11**: 183–190; **33**: 354, 371–373; **45**: 254–264.

EXPERIMENT 96. To study Individual Differences in Controlled Imagination (Class Experiment)

Material. Sheets of paper having at the top six letters (three consonants and three vowels); stop watch.

This experiment has been standardized and material arranged for it.

Procedure. The instructor first explains the method, writing on the board the letters (for example, *a u i p r t*), from which the students make words. The sheets of paper, blank side up, are distributed to all students. At the signal "Ready, go" each student turns over his sheet and writes under the letters as many words as he can in five minutes, using the letters given. The instructor times with the stop watch and all stop at the signal. The instructor now writes on the board the list of permissible words, and the students grade their work on a basis of 1 for each word.

Cautions. Words of one letter are allowed. Proper names may be used, but must begin with a capital letter. No letter may be used more than once in the same word. Obsolete and foreign words are not credited.

Results. Subject's report. State plan or method used in forming words.

Experimenter's report. A table is arranged for a frequency-distribution curve for class results, and the range, average, mode, and median are found.

TABLE XLIV. FREQUENCY, — THE NUMBER OF WORDS BUILT IN THREE MINUTES

SCORE	FREQUENCY	SCORE	FREQUENCY
13	1	26	4
14	2	27	3
15	0	28	2
16	1	29	1
17	2	30	0
18	4	31	0
19	1	32	2
20	4	33	4
21	3	34	0
22	5	35	0
23	9	36	0
24	5	37	1
25	7	38	1

Total, 62
Average score, 23.8

From this table a frequency curve is plotted. In the frequency curve the ordinates are the frequencies, the scores being abscissas.

Discussion of results. Are all members of the class equally familiar with the material? Does this experiment show native or acquired traits? Discuss this point, explaining what native and acquired factors are concerned. Discuss what is shown by the curve. Give examples of the use of controlled imagination.

Give the types of imaginative reaction used in planning a steel bridge; in writing *Paradise Lost, Kubla Khan, David Copperfield*; in daydreaming; in designing a dress; in making an original cake or pie; in designing wall paper; in planning a home; in laying out a garden.

Explain the origin of the imaginary playmates common among children. Give examples of imagination in children's stories. Is it free or controlled?

Inference. Give an inference showing the nature of free and of controlled imagination.

READINGS. **30**: 22–24, 94–95, 104; **35**: 307–373; **45**: 274–282; **47**: 483–485.

EXPERIMENT 97. **To study Constructive Imagination (Two Students)**

Material. Stop watch or clock with second hand; cork half an inch long; two series of words of two sets each, and each set composed of nine words arranged in groups of three, as follows:

SERIES I

Set 1. *a.* pleasure, theater, people
b. wealth, miser, friends
c. plants, root, ground
Set 2. *a.* newspaper, fire, city
b. success, books, information
c. poverty, spendthrift, fortune

SERIES II

Set 1. *a.* water, fish, animal
b. business, invention, machine
c. forest, gun, hunter
Set 2. *a.* cloud, light, moon
b. hay, horse, barn
c. house, brick, mortar

Procedure. E pronounces the three words of group *a*, Set 1, Series I, and requires S to make up a sentence that will have all three words in it. The watch, or count, starts just as E finishes pronouncing the third word and is stopped as soon as S completes a proper

sentence. S writes the sentence, which must be a simple one. A second trial is not permitted, and there is no set time. E proceeds similarly with the other two groups. The procedure of Set 2 is similar to that of Set 1, except that S holds a cork between his front teeth while constructing the sentence. E and S now exchange places and use the words of Series II, including both sets.

Results. *Subject's report.* Give an account of the means and methods used in building the sentences; aids and hindrances; relation between time in building and familiarity with the words.

Experimenter's report. Give the sentences and time in seconds for constructing each.

Discussion of results. Why was S required to use the cork in making sentences of words in Set 2? Would tying the left hand or tying the feet together have made any difference? Did you make use of recall? What part of speech seemed most difficult and yet most important?

The factors of control and purpose enter into constructive imagination. How are these factors shown in this experiment? Give five examples from everyday life of the use of constructive imagination.

This experiment, under prescribed conditions, has been widely used to test intelligence. What aspects of intelligence do you think it tests?

READINGS. **23**: 119, 173; **25**: 143; **36**: 245–248.

EXPERIMENT 98. To determine Imaginal Types of Reaction (Two Students)

A. Verbal Methods.

The nature of centrally aroused imagery is difficult to determine, and as yet no standard tests have been well established. The following exercises are intended to acquaint the student with some of the elementary methods employed.

PRELIMINARY EXPERIMENT

Material. Several lists of words; nonsense figures. Details of the material will be given as needed.

Procedure. 1. Write a detailed account of the imagery used in the following activities: (1) preparing a lesson for recitation; (2) solving problems of arithmetic; (3) imagining scenes and events from oral or written description; (4) oral or written spelling.

2. Give the type of imagery in which you recall the following activities: (1) writing; (2) singing; (3) reading; (4) typewriting; (5) lacing and tying your shoe; (6) relating a story.

3. Indicate the dominant type of imagery that the following conditions are likely to arouse in your own mind: (1) trying to recall a familiar friend; (2) recalling a play at the opera; (3) describing or sketching or painting a scene from memory; (4) silent reading; (5) recalling a fruit-stand.

4. (1) Write a list of words whose objects are characterized by color. (2) Write a list of words whose objects are characterized by sound. Allow the subject four minutes by the stop watch to write each list. Separate the words of each list into the following classes: pure visuals, V.; pure auditory, A.; pure vocal, Voc.; mixed, A. + Voc. + V.; miscellaneous words for which no imagery can be assigned, Misc. Then determine the percentage of each class.

Results. *Subject's report*. Summarize your imagery under the following heads: studying, speech-motor memory, mixed.

Experiment

1. *Spelling Tests* (a comparison of the results of a number of students increases the value).

a. Spelling backwards: oral and written.

Material. Stop watch; list of forty-five polysyllabic words composed of nine to twelve letters each and of moderate difficulty.

Procedure. First ascertain S's normal rate of spelling by using five words of the list. E then pronounces the word and starts the watch at the same time. S spells the word backward orally and pronounces it; the watch is stopped as S pronounces the word. Continue this way for the first twenty words. Proceed similarly with the next twenty, except that S writes the letters of the words from the end to the beginning; the watch is started with the writing of the final letter and stopped at the finishing of the first.

Results. Construct two tables, one for the oral results and the other for the written results. The tables should show what words were spelled correctly and what ones incorrectly, the time required for spelling each word, the average time, M. V., and total errors for each subject.

Compare the dominant type of imagery used here with that reported in the preliminary experiment by each subject. Look for correlations between (1) the number of errors and kinds of imagery used in spelling, and (2) the rate of spelling and the kinds of imagery.

Which form of the backward spelling proved easier, the oral or written? Why?

b. Pronouncing tests: (1) To determine the time for normal pronouncing.

Material. Stop watch; ten polysyllabic words of not more than ten letters.

Procedure. E gives the word to S, letter by letter, in the *normal order*, at the rate of one letter per second. The time between giving the last letter of the word and the pronunciation of the word by the subject is measured by the stop watch and may be termed the pronouncing time.

Results. *Subject's report.* S tells with critical introspection, after pronouncing the list, the method used to hold letters and pronounce words.

Experimenter's report. E records, in tabular form, the pronounced words and reaction time for each.

(2) To determine time of pronouncing words spelled backward.

Material. Stop watch; two series of words of twenty each. The words should be polysyllables, somewhat unusual, and composed of nine to twelve letters.

Procedure. E gives the *first series* of words, letter by letter, in the *reversed order*, at the rate of one letter per second. E starts the stop watch as he begins the word and regulates the rate of spelling by observing the watch. This part of the procedure requires some preliminary practice before the series proper is begun. After the spelling is finished, the watch is allowed to run until the word is pronounced by S. The rate of the pronouncing time is determined as for normal pronouncing. Should S fail to recognize the word at the first spelling, repeat it as often as necessary for recognition, and keep a record of the number of repetitions.

The *second series* differs from the first only in the fact that the letters are given at the rate of two per second.

Results. *Subject's report.* This should consist of an oral report given often by S to E, who records it with the reaction time.

Experimenter's report. Arrange separately the results of the two series of (2). Find the average rate of pronouncing a word and arrange the subjects of the class according to their average rates. Determine also the number of words pronounced after one, two, or three spellings, respectively; then list the subjects according to the number of words pronounced with one spelling. Study the subjects' reports to ascertain the variety of methods or devices used to pronounce the words.

Discussion of results. Do you discover any correlation between the methods and imagery used and the "pronouncing time"?

Is there any correlation between methods and imagery, on the one hand, and the number of spellings necessary for pronunciation, on the other? Do these correlations reveal to any extent the nature of the subject's imaginal type?

What is the relation between spelling and the visual type of imagery in your case?

2. *Memory Tests.*

a. The method of number squares and of letter squares.

Material. Three white cards 2 in. by 2 in., each having three numbers composed of Roman and Arabic numerals arranged according to the order given below; three blank cards for reproduction; metronome or stop watch.

7	VI	8
X	4	V
3	6	IV

Procedure. Expose a card at a time to S for ten seconds, during which time he tries to memorize the numbers in their order. At the end of ten seconds, S counts ten at the rate of one per second and then reproduces the figures in the right order by writing them on the blank cards.

Results. Subject's report. It is assumed that these cards appeal strongly to visual imagery and that success in memorizing them indicates the use and presence of that type. But the subject's report may show the presence and use of auditory and motor imagery as well. To determine the value of each type of imagery when present, use the following arbitrary scale: all figures reported by S as reproduced by a pure memory image (V. or Voc. or A.) are to count 1; all figures given as reproduced by double memories (V. + A. or V. + Voc.) are to count half for each partial memory concerned; and all figures reproduced by triple memories, mixed (V. + A. + Voc.), are to count a third for each partial memory. In addition to this qualitative scale, a second (quantitative) scale[1] is devised to measure the amount of the entire reproduction: here a figure correctly placed counts 1; a figure correctly recalled but misplaced counts $\frac{1}{2}$; a figure substituted counts $\frac{1}{4}$; and an omitted figure counts 0.

To illustrate let

7	VI	8
X	4	V
3	6	IV

be the given square and

[1] Method adapted from Titchener's *Experimental Psychology: Instructor's Manual*, p. 397. By permission of The Macmillan Company.

7	X	8
	4	IV
3	6	V

be the square reproduced.

The subject's report gives the first and third lines as visual imagery, the second as auditory and vocal imagery. The relative values of the imaginal types as shown in these results have been computed by using the arbitrary numerical values. The arithmetic operations may be seen by inspecting the "total values" in Table XLV.

TABLE XLV. COMPARATIVE NUMERICAL VALUES OF IMAGINAL TYPES

LINE	IMAGERY	RIGHT	MIS-PLACED	SUBSTI-TUTED	OMITTED	TOTAL VALUES	
						Value	by Imagery
1	V.	2	1	——	——	10/36 V.	= 20/36
2	A. + Voc.	1	1	——	1	6/36 A.	= 3/36
3	V.	2	1	——	——	10/36 Voc.	= 3/36

Summary. V.: A.: Voc.:: 20 : 3 : 3. Memory = 26/36.

b. Words pronounced alike but spelled differently.

Material. Three blank cards; three series of words pronounced alike but spelled differently. Each series consists of nine words and is arranged on a separate white card, thus:

bare	tale	piece
peace	bear	right
write	rite	tail

Procedure. Expose the stimulus card ten seconds, after which the subject counts ten at the rate of one per second and then reproduces the words on the blank card in the order given on the stimulus card and makes a report of the imagery involved.

Results. Use the same method as in the number squares for determining the qualitative and quantitative values of the imagery involved. It is not likely that substitutions will occur in this case.

c. Words spelled alike but pronounced differently.

Material. Three series of nine words each. There are only five different words in a series as to spelling, but four of the five are pronounced in two different ways; for example:

read	slough	tear
wind	haul	wind
tear	read	slough

Procedure. E pronounces the series twice at the rate of one per second. At the close of the second pronunciation S reproduces the words orally in the order presented and reports on the imagery involved.

Results. Measure the accuracy of the reproduction as in the two former exercises. Study the results for correlations between the amount of the reproduction and the kind of imagery involved.

Compare, if possible, in a similar way the results of at least ten individuals.

Are the results of exercises *a*, *b*, and *c* consistent for each individual? What type of imagery was aroused by the material of exercise *c*?

3. *Motor Tests.*

a. Passive method.

Material. Four nonsense figures, each composed of six lines, some curved and some straight, joined end to end but not forming a closed figure.

Procedure. S, with closed eyes, pencil in hand, is seated at a table as for writing. E guides S's hand over the figure twice in a uniform and continuous fashion. The tracing at the start and the finish should be well marked in order that the movements of the figure may appear as a compact whole. The subject immediately tries to reproduce the figure on a blank sheet, with eyes closed.

Results. Assign to each of the lines of the original figure a value of $8\frac{1}{3}$ per cent (that is, 50 per cent for the six lines) and to each of the five angles a value of 10 per cent (that is, 50 per cent for the five angles). Then the value of the reproduced line is to the value of the original line as the length of the reproduced line is to that of the original. Thus, if an original line is 3.75 in. and the reproduced is 3.125 in., then the value of the latter in terms of the assigned value is

$$x : 8\tfrac{1}{3}\% :: 1\tfrac{1}{8} : 3\tfrac{3}{4}, \text{ or } 7\%, \text{ approximately.}$$

The degree of accuracy of the reproduced angle is similarly determined. In the event that a reproduced line exceeds the original line, determine the percentage of the excess to the original line and deduct it from the assigned value; the remainder is a measure of the accuracy of reproduction.

b. Active method.

Material. Four series of simple patterns composed of six lines cut from cardboard; pencil; sixteen sheets of paper about 6 in. by 8 in.

Procedure. Here the method is active, whereas in *a* it was passive. S, with eyes closed, traces a pattern from beginning to end

by running a pencil in the groove of the card. The movement should be uniform and continuous throughout the tracing. Repeat the tracing once. S then reproduces the pattern, with eyes closed, first in the same position as originally traced, then as turned clockwise through 90, 180, and 270 degrees, respectively.

Results. The accuracy of the reproductions is determined by the method given in exercise 3, *a*, above, both as to lines and as to angles.

Discussion of results. Study the results as recorded in parts 1, 2, 3, 4 of the Preliminary Experiment and results from spelling tests *a* and *b*, memory tests *a* and *b*, and motor tests *a* and *b*, as they relate to individual imaginal types. Are the objective results consistent throughout? Do the subjects' reports support or contradict the objective results? Was there a tendency to describe the figures verbally as you were tracing them in the grooved patterns? Did you move the body or head or roll the eyes while learning the patterns? If you are in doubt as to what you did, repeat two or three patterns again to observe what happens.

READINGS. **9**: 100–108; **13**: 22–137; **41**: 56–57.

B. Method of Serial Impressions.[1] *Group Experiment.*

Material. Printed cards, $2\frac{1}{2}$ in. by 14 in., arranged in six sets of seven each, containing numbers consisting of four, five, six, seven, eight, nine, and ten digits, respectively (since the auditory list does not have to be exposed it may all be written on a large card seen only by the instructor); metronome; tables prepared with five columns headed, respectively, "Number of Card," "Number of Digits," "Number Reproduced," "Correct Number," "Score." These tables are prepared in advance by the students.

Procedure. In this group experiment the class is arranged in amphitheater style. In each method of presentation a preliminary test should be given of a few sets of numbers to accustom the students to the procedure.

1. *Auditory presentation.* S closes his lips firmly and presses his tongue against the roof of his mouth as a prevention against articulation. The metronome is started beating seconds, the signal given, and the instructor pronounces the digits on the first card (four) with the metronome beat, one a second, S hearing but not seeing. After the last digit is pronounced, all say in unison on the next three beats of the metronome, "Get ready, write," beginning at once, on the

[1] Modified and adapted from Whipple's *Manual of Mental and Physical Tests*, Part II, p. 155. By permission of Warwick & York, Inc.

fourth beat, to reproduce on the prepared table, in the proper place, the digits as heard. The same procedure is carried out with the other five series, with a wait of about ten seconds between each presentation. When the student cannot reproduce the proper digit he places a dash instead.

2. *Visual presentation.* In this case the entire card is held up before the class for a length of time equal to that of the auditory presentation, a digit per second. Precautions are taken as before to reduce any tendency to articulatory reproduction. S only sees. The reproduction is made as above.

3. *Auditory-visual presentation.* In this case the digits are written on the back of the card, and as E shows the card he pronounces the digits as in procedure 1. S both sees and hears.

4. *Auditory-visual-articulatory presentation.* The presentation is as in procedure 3, except that S pronounces the digits in unison with the instructor. S sees, hears, and articulates.

5. *Auditory-visual-hand-motor presentation.* The instructor pronounces and exposes the digits as in procedure 3, and S writes in unison on scrap paper. He then discards the scrap paper and reproduces after the usual interval. S sees, hears, and writes.

Results. The instructor reads the digits as given and the students enter the proper numbers in their respective places in the table in the column headed "Correct Number."[1]

Scoring. Every omission is scored as one error; every displacement by one or two places is scored as half an error; every displacement by three or more places as one error. The memory span in each case is the maximal number of digits reproduced without error. This is shown in the table.

After the scoring the different series should be compared as to error. The imaginal type is found from the highest span. An array of the spans of all students should be made and written on the board, either at the experiment period or when handed in.

In an article in the *Journal of Experimental Psychology*, for October, 1916 (pp. 393–403), Gates estimates the spans as follows:

Average span for Auditory is 7.666.
Average span for Visual is 8.172.

Compare your results and those of the class with this standard.

Discussions of results. Why did you not reproduce directly, with no interval? Why did you not have a silent interval? How would

[1] When students report the full number correctly reproduced as nine or ten digits, the chances are that they have not adhered to the conditions of the problem.

you have stated your imaginal type before this series of experiments? Does what you have found here check with your method of memorizing? How do these results compare with the results obtained in the preceding experiment? Discuss the subject of imaginal type as it relates to occupation, giving illustrations from your own experience or observation.

Mention some practical applications of the principles illustrated by this experiment in the common affairs of daily life. What is the value of a broad educational basis from the standpoint of imaginal types?

How can one infer from an author's writings his dominant imaginal types? What type is suggested by Tennyson's "Bugle Song"? by Wordsworth's sonnet, given on page 254? How could the deaf Beethoven compose his symphonies? Explain the process when a poem or a melody continually "runs in one's head." To what kind of type would this point?

Do you, for the most part, hear, see, or articulate your thoughts? What type of imagery is most commonly found in the thought of children? Illustrate from your observation and experience.

READINGS. **6**: 229–258; **9**: 113–115, 123–127; **37**: 391–394; **45**: 150–160; **47**: 368–371.

EXERCISES

1. Recall the longest week or day and also the shortest week or day that you can remember, and tell which of them was most crowded with events. Can you explain? If your facts indicate a law of memory, formulate it.

2. A certain system of mnemonics made use of a dozen or more words in a fixed sequence. The list of the presidents of the United States was learned by associating each name with the word corresponding to it in position on the list. The same list of words was used in memorizing, no matter what was desired to be remembered, — the names of the apostles, the planets in order, a poem, etc., — the task consisting in forming associations of the various units in the memory problem with the words in order. Comment on the fallacy of such a system.

3. Why does a single word from a prompter bring back the forgotten part?

4. How do you memorize? What psychological laws support your method? What improvements might you make?

5. Why does one usually remember poetry better than prose? What elements of poetry tend to favor retention?

6. Is it better to study a lesson all at one sitting or at two or more periods with equal time intervals?

7. When one is "rattled" (associative and affective inhibition), what is the best method to pursue?

8. What kind of memory, rote or logical, is required in learning each of the following items: a list of the presidents, dates in history, the names of the planets in order, a chapter in history, a theorem in geometry?

9. How many of the senses give experience which may be recalled in the form of images? Which sense gives it most readily?

10. Name several factors upon which a good memory depends.

11. Give some advantages of forgetting.

12. What phases of memory are native? What phases are improvable?

13. In practical affairs which is it more profitable to recall readily, a person's name or his face? What cues might you use to insure this recall?

14. Give an example of imagination in play. Is it free or controlled?

15. What is the psychological value of the recitation method as opposed to the lecture method of teaching?

16. Explain how a good memory and a fertile imagination promote originality, and show how Edison's achievements support your statements.

17. What is the factor in the Bon Ami advertisement that makes it so effective? Give another advertisement that is easily remembered.

18. Distinguish between the characteristics of night-dreams and day-dreams.

19. How may one improve one's imagination?

20. "I have a story, but cannot give time, place, or circumstances under which I heard it." What phase of memory is lacking?

21. I am trying to think of the name of a friend, and I remark, "The name is on the tip of my tongue." What phase of memory is lacking?

22. Should one begin to learn German and French in the same year? (See Experiment 93.)

23. Recall stories you have heard children tell and compare their imagination with that of adults. Is it more creative or imitative? more or less organized?

24. Take some great novelist, as George Meredith, and note whether what he constructs is true to life or merely fanciful. In what does constructive imagination consist?

25. Explain why the study of science requires and should cultivate the highest form of imagination, using some special example from your knowledge of biology, chemistry, or physics.

26. Read in some late astronomy accounts of the hypotheses concerning the origin of the solar system. Show how they illustrate constructive imagination.

27. What relation has the imagination to the art of getting on peaceably with one's fellow men?

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CHAPTER X

REASONING

1. We may define it [reasoning] . . . as purposive thinking carried on in the interests of some plan which we wish to execute, some problem which we wish to solve, some difficulty which we wish to surmount. — J. R. ANGELL, *Psychology*, p. 223

2. Rational thinking, or *reasoning*, is another special kind of thinking. Dreams and hypnosis are lower and less organized than casual thinking, while reasoning is a higher, more adaptive variety. The stream of rational thoughts is made up of concepts and judgments; the succession is determined by their meaning instead of by mere similarity and contiguity, as in casual thinking. — H. C. WARREN, *Elements of Human Psychology*, pp. 322–323

3. Reasoning as a whole is a process of mental exploration culminating in inference. . . . Psychology studies the process of reasoning, while logic checks up the result and shows whether it is valid or not. Logic cares nothing about the exploratory process, but limits itself to inference alone. — R. S. WOODWORTH, *Psychology*, pp. 468, 475

TOPICAL OUTLINE

General Nature of Reasoning
- *A*. Degree of complexity and rank of adaptive service
  - I. Involves all other responses, serves as an index to their strength and organization and responsiveness
  - II. Extends adaptive responses far beyond the innate and habitual
- *B*. Relation to other responses
  - I. Overt and explicit: similar in results but unlike in modes of response
  - II. Glandular: involves much feeling, less reasoning
  - III. Feelings and attitudes: strengthens and directs the course of reasoning

Stimuli to Reason
- *A*. Situations and difficulties for which responses are not provided
  - I. In technical, mechanical, and fine arts
  - II. In human intercourse of daily life: family, marital, social, and business relations
- *B*. Sudden and unexpected changes in environment
  - I. Changes and catastrophes of nature: extremes of temperature, storms, floods, famine, disease, etc.

II. Sudden and radical changes in
1. Industry, economics, commerce
2. Ideas (political, religious)
3. Attitudes and tastes: customs, fashions, social standards

C. Tendencies to wonder, to doubt, and to be curious (implicit stimuli)
I. Wonder incites reason to solve the unknown in nature
II. Doubt may impel reason to remove uncertainty and indecision
III. Curiosity stimulates reason to change the strange and unfamiliar to definite and controlled conditions

Reactions of Reason

A. Meaning
I. Origin: innate and acquired
II. Referential significance: to objects, to actions, to uses

B. Concept
I. Origin: acquired
II. Nature: condenses and integrates many particulars into a unitary whole; its function is to *mean*, to classify
III. Relation to
1. Percepts
2. Images
3. Judgments

C. Judgment
I. Genetic relation between concept and judgment
II. Nature of judgment responses
1. Implicit
2. Orientive
3. Predictive
III. Function: produces definite orientation in attitudes

D. Inference: a response to two judgments

Results of Reasoning

A. Effects on experience
I. Organizes it in the form of knowledge
II. Tests and evaluates
III. Reduces trial-and-error responses
IV. Inhibits impulses and feelings

B. Effects on overt responses
I. Inhibits or redirects them
II. Promotes economy of effort

C. Effects on social intercourse
I. Sets plans and standards for coöperation
II. Promotes social adjustments and eliminates causes of strife

INTRODUCTION

On account of its high service and great complexity reason forms the capstone to man's mental powers. One's senses may be impaired in part, one's feelings abated and memories dimmed,

and yet if one's rational behavior maintains a consistent course, the moral, social, and intellectual life will remain within normal and conventional limits. This very complexity and high service of reason, however much it may increase the difficulties of experimentation, adds to the importance of understanding it as far as we may. As in perceiving and in learning, so in reasoning, previous experience, associations, habits, attention, and motivation are involved, and often in a more exacting way, owing to the stress exerted by a more lively purpose. But the responses of reason are implicit, orientive, predictive, evaluating, and nonperformative in the motor sense (**1**: 223–224).

The stimulus to reason. The things that cause us to reason are legion. In a general way it may be said that such responses occur whenever one encounters variations in his environment to which neither his habitual nor his instinctive organization can successfully respond. Again, one is said to reason when his desires and purposes are so thwarted (**17**: 408–409) that they cannot be satisfied by the usual responses of habit. For purposes of description the stimuli and problems may be grouped as follows: (1) problems that arise from encountering natural forces, as extremes of temperature, storms, pestilence, famine, etc.; (2) problems created by normal human needs, as food, shelter, raiment, and by human intercourse, as justice, competition, revenge, partnership; (3) problems of an abstract and of a noneconomical sort, as problems intentionally set for the joy of solving them, problems that arouse the inclination to doubt, to wonder, and to be curious and to acquire knowledge beyond immediate use.

The responses of reason. As in the study of attention and of feeling, so in the study of reason it is best to begin with those segments of reaction arcs that have become integrated into attitudes, habits, and interests. Such integrations form the neural basis for the permanent features so characteristic of meaning, concept, and judgment. In considering attention it was observed that attitudes are neural patterns which determine the character of a response in more or less disregard of the stimulus; that the responses depend primarily upon the organi-

zation of attitudes; that they are in part innate and in part acquired. We must look to the acquired portions to find the basic mechanisms of reasoning, as it is there that meaning, recognizing, conceiving, and judging have their origin, and these are the primal factors in rational behavior.

Meaning. A response has meaning when it symbolizes something: most often the "something" is a possible action or use. Reactions of meaning are not directly connected with overt "performative responses" as in the case of perception, but rather are confined to those segments that prefigure, orient, and stand for perceptual reactions. "Meaning responses are not reactions to what things are, but to what they stand for on the basis of the persons' previous contacts with them" (**11**: 388–393). When two discrete and separate meanings are embraced in the same response a third emerges which is also orientive and predictive in character. Such responses may combine very simple or very complex meanings. Mere sense impressions may be combined into a predictive response, even in animals of a low order of intelligence. One writer describes how his chicks learned from a single experience to avoid a certain caterpillar because of its disagreeable taste. The two apparently dominant impressions in the case were visual and gustatory, and, owing to the disagreeable quality of the latter, the chicks did not attempt even a second experience. The bitter taste conditioned the visual impression for an avoiding response — wiping the bill in the air! Two impressions were conjoined in the same reaction so that the subsequent appearance of one meant the other (**16**: 96–98). One may hear the name of an interesting plant and henceforth the name stands for the plant.

Concept (**17**: 417–424). When one and the same stimulus is constantly conjoined with many and diverse sorts in the same reaction systems, the former stimulus may become largely detached from the latter, — relieved from the stress, as it were, of initiating an immediate overt response, — and assume a referential significance. An object, ball, or a quality, blue, is reacted to in connection with many different sorts of stimuli, all of which in time tend to fall away, leaving the object or quality in an

independent abstract status which stands for all objects of its class, and may be used to indicate individuals of the class. Such an object or quality is a concept and the reaction a conception. Obviously the conceptual character turns upon the range of its meaning and the extent of its reference. The concept is well illustrated by the common noun and the verb (**20**: 521–532).

Judgment. But even though concepts are detached from immediate mechanisms of response, they can nevertheless arouse overt reactions and other concepts and in turn be aroused by them, as may be observed in their interpretative and classifying functions (**1**: 223–234). In the statement "the piano is out of tune," a particular object, a perception, is related or conjoined to a concept, a condition ("out of tune"). A response by which two concepts, or a percept and a concept, or two percepts are related forms a judgment. This statement fails to show that before a judgment can occur at least two successive reactions must be made (these may both be implicit, or both explicit, or one explicit and the other implicit); the judgment reaction then follows, perceiving the relation between the other two (**17**: 424–427).

Inference. Let us suppose that the mistuned piano is a factor in a prospective musical entertainment; the two facts then become related in a significant way and create a stimulus for further reactions. Just what these will be depends upon the individual's purpose, the control of his experience, and the nature of his environment. If a piano-tuner were near and the individual recalled the fact, the next response might be "call in the piano-tuner." Observe that such a reaction grows out of the relation between the mistuned piano and the musical entertainment. "Call the piano-tuner" is a third response, a third fact, developed from the other two, and as such is a judgment, but owing to the fact that the response consists in perceiving the relation between two judgments it is termed an inference,[1] the characteristic feature of reasoning (**10**: 329–343).

[1] The student is cautioned not to regard these successive judgments as conforming to the requirements of logic. The logician would insist that intermediate steps have been omitted.

Proof. The person responsible for the condition of the instrument may believe that he has solved the difficulty by employing the services of a tuner, but if the latter's skill is questioned, the solution of the problem may be held in abeyance until the harmony of the keys is tested by a pianist. Such additional procedure constitutes a proof in rational behavior (**17**: 430–436).

Results of reasoning. The popular view of reasoning credits it with discovering knowledge. The view is correct if it be taken to mean that reasoning organizes experience and shapes it for predictive, orientive, and evaluating functions. The effects may be regarded as immediate or remote: the former are used to improve one's welfare, or to make a new attack on a difficulty, or to dismiss it altogether; the latter function as controls, norms, and standards in the larger relations of human affairs as seen in industry, economics, government, and science.

The effect of reasoning on the individual cannot be fully appraised owing to the many indeterminate factors involved. The judgment offers, perhaps, the most favorable vantage point from which to observe rational behavior. A direct effect of the judgment appears to be the formation of a definite attitude toward a situation, and if the attitude assumes some degree of permanency it constitutes a belief, — a concrete and dynamic effect. But belief is only one result of rational behavior; the thoughtful man is regarded as prudent and cautious in action and as critical in observation; then, too, the consciousness of power to solve problems and remove difficulties by rational means predisposes us to adopt such behavior in preference to impulsive and emotional types (**13**: 399–416; **17**: 430–433).

Experiment 99. **To study Meaningful Attitudes (Two Students)**

Material. Stop watch; two lists of five words each:

List I	List II
base	agnostic
bar	republican
fresh	bolshevik
note	socialist
row	democrat

Procedure. E uses the words in List I and S, when E is subject, uses the words in List II. E spells and pronounces one word of his list and requests S to observe and record with care the several meanings of the word that may occur in one minute. S must not force a change of meaning nor resist the appearance of a new one; he must keep the word in mind and observe both explicit and implicit responses to it, such as verbal imagery; initial vocal responses; movements of eyes, hands, body; feelings, pleasant or unpleasant; desires. At the end of a minute E calls "Time" and allows S sufficient time to complete his record. Three or more meaning responses must be given to a word. E now pronounces the word a second time and S continues to observe meanings as before for one minute and makes an after-record. E and S now exchange places and a word from List II is pronounced and responses of meaning are recorded and repeated under the same conditions used with List I. A second word from List I is now pronounced to the first subject and the same procedure is observed. E and S now alternate until they have finished the five words of the respective lists.

Results. A sample record of a word is given here.

TABLE XLVI. REPORT OF IMPLICIT AND EXPLICIT RESPONSES OF MEANING

WORD	NUMBER OF TRIALS	RESPONSES OF MEANING				
		Implicit	Explicit			
			Face	*Head*	*Hands*	*Body*
Fork	1	Angle between two branches of tree. Visual imagery of bark moss	Eyes rolling	Tipped back		
	2	Table fork. Two prongs, incipient jabbing movements		Down	Mimetic movements	
	3	Road. Visual imagery of diverging white gravel roads	Eye movements	Poised for far looking		Erect
	4	Fork it over. Auditory imagery in threatening tone	Eyes squinting	Tossed back	Initial jerking movements	Stiffening

Discussion of results. In any response were you doubtful of the meaning? Were you doubtful of the imagery? Which was clearer, the meaning or the imagery? Do you feel sure that you expressed

all the overt responses? Go over both the implicit and the explicit lists and place a minus sign before the phrase or words in which you place little confidence as facts; place a plus sign in front of those in which you place some confidence as facts; and place a check mark (✓) before those in which you place a high degree of confidence. Do the explicit or the implicit responses show the higher degree of confidence?

Inference. State character of meaningful attitudes based on results.

READINGS. 1: 203–222; 17: 410–414; 20: 367–373.

EXPERIMENT 100. To study Comprehension (Group Experiment)

Material. Stop watch; five questions involving experiences of daily life.

QUESTIONS

1. What should you do if a friend gave you a letter to mail and you forgot to mail it for several days?
2. Why should women and children be saved first in a shipwreck?
3. What should you do with a two-year-old child that you found lost on a city street?
4. Why are people who are born deaf usually dumb?
5. Why is a man who borrows money willing to pay interest on it?

Procedure. The instructor tells the students that he is going to ask them five questions and that the answers are to be found largely in the experiences of daily life; that a question will be read twice and ten minutes allowed for answering it and describing the responses involved in reaching an answer. Two answers may be given: a first and a second best. Point out for each of the two answers to a question the facts that finally determined it.

Results. Subject's report. Record the answers in the order of the questions.

Discussion of results. Do any of your answers report a memory based upon observations made on conditions involved in the questions? Do you regard such an answer as one based upon comprehension? Why? Do you recognize in any of the answers only a small part of your own experience? How do you account for the presence of the rest of the facts necessary to an answer? Were any of your answers based upon consequences that you foresaw rather than upon definite information? But consequences as imagined facts must have a source. Can you identify the source in this case?

Did the facts suggest the answers by association or were the answers abstracted from the facts?

Comprehension is sometimes regarded as a synonym for common sense. Do the results of this experiment justify such a view? Are the problems of comprehension largely social or are they individual and private in their reference?

One author observes that there are two ways of thinking: (1) "thinking out" and (2) "thinking about" our affairs and problems or those of other people. Which type of thinking is more closely allied to comprehension?

Inference. What is comprehension?

READINGS. 2: 317–334; 6: 116–134; 20: 367–373.

EXPERIMENT 101. To observe Thought Reactions to Arithmetic Problems

Material. A. Problems in common arithmetic with indicated operations; some of the digits of the numbers are replaced by x's.

1. $x9x + x7 - 33 = 411$.
2. $x85 + 4x5 + 26x = x737$.
3. $40x4 \div 7x = x2$.
4. $x6x6 \div x = 1924$.

Procedure. Solving these problems consists, of course, in replacing the x's by proper digits. Observe the nature of your reaction in each step leading to the correct substitution, such as looking for a cue, using a general principle, making a trial more or less blindly, solving the problem mechanically.

Results. Arrange your report to give the following data under the proper headings: (1) state what is given and what is required; (2) write out the operation; (3) give the arithmetical principle employed or methods used.

Material. B. Common problems in algebra and geometry:

1. Prove that the sum of the three angles of a triangle is equal to two right angles.
2. Find two numbers such that twice the first plus three times the second is equal to 105; and three times the first plus twice the second is 95.
3. The sum of two numbers is 20, and the first is to the second as $\frac{1}{2}$ is to $\frac{1}{3}$; what are the numbers?
4. The sum of two numbers is 31, and their difference is 5; what are the numbers?

Procedure. Since these problems are all formal and are fairly well known, state the service that knowledge plays in solving each problem. It is suggested that a formal procedure be adopted, stating what is given, what is required, searching for a principle, applying the principle, and giving methods of checking.

Results. Describe your reactions in solving each problem, including search for a cue; use of imagery (visual, vocal); aid from pen or pencil, if used; use of old habits; drawing inferences from comparisons. Point out the steps and inferences that you made from responding to two or more facts.

Material. C. Problems in "mental" arithmetic:

1. A has three times as many apples as B, and B has twice as many as C; how many has each if A has 12 more than B and C together?
2. Three fifths of A's age was his wife's age when they were married, but in forty years four fifths of his age equals hers; what was the age of each when they were married?
3. A man bought hay for $8 a ton, but in getting it he lost 20 per cent on it; what did it really cost him a ton?
4. Two men, A and B, in partnership gain $300. A owns two thirds of the stock, lacking $40, and gains $180; required, the whole stock and the share of each.

Procedure. These problems are to be solved without the aid of pen and paper. (Is this unusual for you?) Use pen and paper only to record the solution, the number of trials and fresh attempts, the causes for your abandoning a line of attack. After you have solved the problem mentally, write out your solution step by step.

Results. Report the number of steps for each solution. Point out principles that were applied, the prevailing imagery that you had whether visual, auditory, or vocal. Which seemed of greater service? Have you any habits that aided you? any information or knowledge? Which is of greater service in solving such problems; training in such work or information (that is, conscious knowledge of how to work them)? Can one of normal intelligence solve such problems without education? It is generally thought that feeling is incompatible with reasoning. Do your experiences in solving these problems support or refute that notion?

Did you give up at any time? If so, what is the cause of such a reaction? Is there any connection between such a condition and that of despair?

READINGS. 1: 224–225; 8: 490–503; 9: 325–331.

EXPERIMENT 102. To study the Habit Factor in Reasoning (Two Students)

Material. Stop watch or Sanford chronoscope; prepared blanks for recording S's responses; two series of time problems: Series I of one hundred questions in which are given two dates and one day —

to find the other day; and Series II of one hundred questions in which are given two days and one date — to find the other date.

Ten examples of each series are given below, which may furnish a basis upon which E and S, respectively, construct one hundred or more questions.

In Series I the questions involve a constant order of days so that each day of the week is involved the same number of times; for example, the order may be Thursday given in the first question, Wednesday in the second question, and Sunday, Saturday, Tuesday, Friday, Monday, each in turn, appearing in the round of questions. Also the time intervals between the given day and the required day occur in a fixed order, for example, + 6, − 8, + 4, − 5. The plus signs indicate that the required day is in the future and the minus signs indicate the past. The following ten questions will suffice to show the method of construction for Series I:

1. If Thursday is the fifteenth, what day is the twenty-first?
2. If Wednesday is the twenty-seventh, what day was the nineteenth?
3. If Sunday is the fourth, what day is the eighth?
4. If Saturday is the nineteenth, what day was the fourteenth?
5. If Tuesday is the seventeenth, what day is the twenty-third?
6. If Friday is the eleventh, what day was the third?
7. If Monday is the eighth, what day is the twelfth?
8. If Thursday is the twenty-ninth, what day was the twenty-fourth?
9. If Wednesday is the twenty-first, what day is the twenty-seventh?
10. If Sunday is the thirteenth, what day was the fifth?

The order of days should differ in Series II and may run as follows: Saturday, Monday, Thursday, Tuesday, Friday, Sunday, and Wednesday. The time intervals may include the same numbers or different ones. If the same, they should refer to time in the opposite direction to that of the same numbers in Series I; for example, + 8, − 6, + 5, − 4. The following questions furnish a basis for constructing Series II:

1. If Saturday is the twenty-third, what is the date of next Sunday?
2. If Monday is the nineteenth, what was the date of last Tuesday?
3. If Thursday is the tenth, what is the date of next Tuesday?
4. If Tuesday is the eighteenth, what was the date of last Friday?
5. If Friday is the fourth, what is the date of next Saturday?
6. If Sunday is the twelfth, what was the date of last Monday?
7. If Wednesday is the sixteenth, what is the date of next Monday?
8. If Saturday is the fourteenth, what was the date of last Tuesday?
9. If Monday is the twenty-second, what is the date of next Tuesday?
10. If Thursday is the eighth, what was the date of last Saturday? etc.

Procedure. E divides the list of one hundred questions into five sets of twenty each. Should the series prove too short for S to develop adequate methods of reasoning, E prepares another series of one hundred questions. E should maintain a uniform manner and an even tone of voice and adhere strictly to the same phraseology in putting the questions. The stop watch (or key to the chronoscope) is released simultaneously with the pronunciation of the second date in Series I (for example, in question 1 the key is released at the pronunciation of "twenty-first"), and the watch is stopped (or counting the swings of the pendulum ceases) when S responds with the correct day. S is asked to report from time to time the manner in which the responses are worked out. E also records the time in seconds and keeps an account of S's overt behavior while solving a problem.

Results. Subject's report. This should contain a careful description of the methods employed in solving the problems, such as old habits, bodily and mental; type of imagery, if any used; tension and relaxation of feelings while S was listening to the conditions of the problem, solving it, and giving the answer.

Experimenter's report. This consists of a table in two parts, one showing the number of the problem and the time when the date is future, and the part showing the number of problem and the time in seconds when the time is past. The following is a typical table of the mean averages of plus and minus time for answers to ten sets of Series II.

TABLE XLVII. THE EFFECT OF HABITS ON THE RATE OF SOLVING PROBLEMS

		Number of Problem									
		1	2	3	4	5	6	7	8	9	10
Mean averages	+	4.60	4.04	3.40	2.52	3.38	2.56	1.86	2.34	2.84	2.52
	−	6.00	5.14	4.10	3.64	3.50	3.22	2.34	2.60	3.60	3.30

Discussion of results. A learning curve should be plotted, showing the number of periods on the base line, or abscissas. E's report should also contain a list of the observable facts of S's bodily behavior; use of hands and arms, movements of the facial muscles, closing and opening the eyes, posing of the body, uses of the voice.

Was the method that you used gradually developed or did you hit upon it at once? Is there any appreciable and constant difference in the time required to determine a past date when the given date is

an odd number from that when the latter date is an even number? Do the tables show a constant difference in time between responses to future dates or days and responses to past dates or days? If so, has habit anything to do with the difference?

List all the facts that you have found which tend to show the effect of habit on reasoning. Do you also find evidence showing the effect of imagery on reasoning?

READINGS. 2: 370–379; 9: 363–370; 12: 633–638; 17: 427–430.

EXPERIMENT 103. To study Problems in Formal Reasoning

Material. Ten syllogisms composed of propositions having abstract terms, and ten syllogisms composed of propositions having concrete terms. (The object of using problems expressed in logical form is twofold: (1) it reduces the conditions of the problems to simple standard form; and (2) it makes it possible to observe the effects of abstract and concrete material, respectively, upon the accuracy, speed, and effort in reasoning.)

SERIES I. SYLLOGISMS WITH ABSTRACT TERMS

1. All *A* is *B*.
   All *C* is *A*.
   Therefore ——.
2. All *A* is *B*.
   Some *C* is *A*.
   Therefore ——.
3. All *A* is *B*.
   All *B* is *C*.
   Therefore ——.
4. Some *A* is *B*.
   No *B* is *C*.
   Therefore ——.
5. All *A* is *B*.
   No *B* is *C*.
   Therefore ——.
6. Some *A* is *B*.
   All *B* is *C*.
   Therefore ——.
7. No *A* is *B*.
   All *B* is *C*.
   Therefore ——.
8. No *A* is *B*.
   All *C* is *B*.
   Therefore ——.
9. All *A* is *B*.
   No *C* is *B*.
   Therefore ——.
10. All *B* is *A*.
    All *B* is *C*.
    Therefore ——.

SERIES II. SYLLOGISMS WITH CONCRETE TERMS

1. All rodents have chisel teeth.
   A gopher is a rodent.
   Therefore ——.
2. All masons use trowels.
   Some Yankees are masons.
   Therefore ——.

3. All turtles have shell armor.
   All shell armor gives protection.
   Therefore ——.
4. Some blacksmiths are negroes.
   No negro is an aviator.
   Therefore ——.
5. All members of the Boat Club are members of the Gun Club.
   No member of the Gun Club is a woman.
   Therefore ——.
6. Some members of the Boat Club are members of the Gun Club.
   All members of the Gun Club are good marksmen.
   Therefore ——.
7. No farmers are speculators.
   All speculators take chances.
   Therefore ——.
8. No farmers are speculators.
   All brokers are speculators.
   Therefore ——.
9. All farmers are frugal.
   No broker is frugal.
   Therefore. ——.
10. All naturalists are good observers.
    All naturalists are lovers of nature.
    Therefore ——.

Procedure. S provides two sheets of paper on which to record the conclusions to the problems of Series A and Series B, respectively. Number the conclusions from 1 to 10, each number corresponding to that of the problem. In order to distribute the effects of habit over both series, solve first problem 1 of Series A and then problem 10 of Series B, then problem 2 of Series A and problem 9 of Series B, and so on to the end. Skip none and write under each conclusion as soon as it is recorded (sufficient space being allowed) an account of how you solved the problem; use diagrams and drawings if they will aid your description. Since speed is one of the factors to be studied, S must record the time in minutes that elapses between starting and completing the solution for each problem in both series. After completing both series check your solutions with those given in the Appendix. Make a cross (×) in front of your wrong conclusions.

Results. The raw results on the two sheets of paper furnish evidence for comparing the effects of concrete and abstract terms in syllogisms on the rate, accuracy, and degree of effort in reasoning.

Discussion of results. What do results show regarding these three factors as to time? as to accuracy? as to effort? Is there any rela-

tion between accuracy and degree of effort?[1] Do any of your solutions (inferences) contain new facts? If so, make a list of them, and determine as far as you can if they are entirely independent of previous experience. Do you conclude that the results of reasoning are new or creative? In what does the newness consist? What is the difference between the psychology of reasoning and the logic of reasoning?

READINGS. **3**: 240–248; **4**: 84–189; **15**: 1–39; **17**: 433–435; **21**: 474–478

EXPERIMENT 104. To study Understanding and Reasoning in solving Complex Concrete Problems

Material. Five concrete problems varying in complexity.

1. In one pan of a false balance a roll of butter weighs 1 lb. 9 oz., and in the other, 2 lb. 4 oz. Find the true weight of the butter.
2. A rise of 5° on a centigrade thermometer is equal to how many degrees' rise on a Fahrenheit thermometer?
3. A spider is at the foot of a fifty-foot chimney, and every time it climbs a web running to the top it ascends 5 ft. and drops back 4 ft. How many trials will it take the spider to reach the top of the chimney?
4. A man travels three quarters of his journey and then returns toward the starting-point two thirds of the distance traveled. He now continues the journey one half of the distance retraced and then stops. What part of the whole distance is marked by the last stopping-place?
5. A one-track railroad has a switch which will hold twenty-five cars and one engine. This switch is connected at each end with the main track. Two fifty-car trains (A and B), each having but one engine, meet and must pass at the switch. What order of shifting of cars is necessary in order that the trains may pass each other?[2]

Procedure. The problems are not related, but they do increase in complexity, and for that reason should be solved in the order presented, beginning with problem 1. The value of solving a problem for the present study depends entirely upon the accuracy and clearness of the description of the reactions involved. Let the task be to keep track of (1) the number of plans tried on each problem; (2) the number of trials given to a plan and the reason for its success or failure; (3) whether a useful principle or cue was discovered by chance or by the recall of pertinent knowledge or as an inference from the comparison of facts; (4) whether the solution came sud-

[1] This experiment was suggested by a comment made by Dr. F. Kuhlmann in his *Handbook of Mental Tests*, p. 182.

[2] Problem 5 is taken from Morgan's "Mental Tests," by Dr. J. J. B. Morgan, as quoted by Professor J. F. Dashiell, in the *Psychological Review*, 1925.

denly, "like a flash," or was developed step by step. Observe also the explicit responses involved, as tendency to vocalization and to eye and hand movements, tendency to posing of the body, and tendency to efforts of concentration. The absence of a time limit favors accuracy and clearness in describing the processes involved.

Results. Report the results in two parts: (1) correct operations involved in solving the problem as such (check your answers with those in the Appendix); (2) tabular form of the responses that occurred in solving the problems, with these headings:

Problem	Number of Plan	How Derived	Number of Trials	Cause of Rejection	Explicit Responses

Discussion of results. What evidence do you find that reasoning involves selection as well as rejection of plans and ideas? By what processes do plans and ideas appear? When do plans and ideas become selected? What principle was most often successful: one discovered by chance, or one arising from knowledge, or one inferred from facts?

Are the implicit responses entirely distinct from the explicit or are the latter an extension and accompaniment of the former? Are the explicit responses essential or irrelevant?

Readings. **2**: 335–383; **5**: 69–73; **19**: 264–273.

EXERCISES

1. Explain why dream reactions are the opposite of reasoning reactions.

2. Few clouds are ever observed on the surface of the planet Mars. The white polar caps vary in size. When it is summer in the Northern Hemisphere, the north polar cap rapidly shrinks in size, while the south polar cap grows larger, and the opposite conditions are true in winter.

A network of long straight lines has been made out by some observers in the central portion of the disk, these lines apparently starting from the polar caps.

Nature does not make long straight lines.

Can you make a connected argument from the above statements that Mars is inhabited by intelligent beings, in view of the additional fact that temperature conditions do not entirely preclude such a conclusion?

3. Give a concrete example tending to show that a college freshman often has an exaggerated notion of the value of his own town, so that his judgments and reasoning are biased by it. What are some of the influences tending to give him an impartial view by his senior year?

4. To illustrate the suddenness often attending the discovery of a scientific law, Oersted's discovery of the connection between electricity and magnetism may be used. For a long time it had been supposed that such a connection must exist, and Oersted had made frequent attempts to prove it experimentally, without success. The Danish professor was lecturing to his class, a suspended magnetic needle was before him, and close by a wire carrying a current from a battery. He suddenly announced to his class what he was about to do, and raised the wire, holding it above the needle, not touching it, and parallel to it. At once the needle swung to one side, and remained at a considerable angle to the wire — and modern electricity was born. Explain imaginative and reasoning reactions.

5. In a small town an important election involving the issue between Wets and Drys was held one Saturday night. The church people were out in force, and at the end the day was saved for the Drys after a close contest. The Presbyterian minister, after valiantly doing his part, was informed just before the end that the day was lost, and, thoroughly discouraged, went home. Closely engaged in his study, and too disheartened to venture out the next morning, he ascended his pulpit and preached a sermon appropriate to the lost cause, the climax being reached as he described how he heard from his home late the night before "the drunken yells of the victors."

Point out the probable emotions, associations, and attitudes influencing the clergyman's reasoning. Upon what did his error depend?

6. If one fills a small glass tube with iron filings, and strokes it with a strong magnet, always in the same direction, the filings will be seen to arrange themselves in the direction of their length along the longer axis of the tube. The tube, if it is lifted gently, will now at the same end repel one pole of a small compass and attract the other. The tube is therefore a magnet. If now the tube is thoroughly shaken, one end of it will attract both poles of the compass alike. It is therefore not a magnet at this time.

A sewing needle is magnetized by stroking with a bar magnet. Tested by the compass it is seen to be a magnet. It is heated red hot and allowed to cool several times, after which the compass test shows no magnetism. Heat is molecular motion.

A needle is magnetized and sharply jarred many times. The magnetism disappears.

From the above statements derive the theory that magnetism is a matter of molecular arrangement.

7. It is said that the astronomer Kepler made and abandoned many false hypotheses, working for twenty years, testing out each by mathematics, before he announced his laws of planetary motion. What attitude did he show? What kind of imagination did he use? This type of reasoning is sometimes called verification. Can you give another example of it?

8. The planet Uranus was noticed to vary from the predicted position it was expected to occupy at a certain time. Two young astronomers, Leverrier in France and Adams in England, unknown to each other, set to work to find the cause. By the laws of mathematics each found that the slight variation in movement was caused by the presence of an unknown body near it in the heavens. Leverrier wrote to a German astronomer directing him to look in a certain position in the sky for the unknown body. The great telescope was pointed in the direction indicated, and less than one degree from the exact point mentioned a new planet was found serenely shining in the sky. Thus Neptune was discovered. In an exactly similar manner, under the direction of Adams, the same planet was located by the telescope at Cambridge. Fill out the following blanks:

The first step in the process consisted in —— of the —— in the —— of the planet Uranus. The second step was an —— constructed by the ——. The third step was the —— of the —— through the —— of ——. The fourth step was the —— of the new —— itself, whose —— verified the ——.

9. A little boy who had just moved from the country to town passed by two reservoirs on a hill near where he was living. "Is one for hot and one for cold water, mother?" he asked. What was his reasoning process and what error did it contain?

10. A man desired his son to have a college education. The son wished to go into business and disliked study. The father persisted, and the son spent four years at college, threw away his time, became idle and discontented, and in the end made a failure of life. Show the error in the father's reasoning.

11. Show by referring to some examples given above and by an example from your own experience that, as Woodworth says, "reasoning may be called a trial and error process in the sphere of mental reactions."

12. Give examples from the foregoing exercises, and an example of your own, of two important attitudes operating in reasoning: (1) the critical attitude toward supposed facts (the scientific attitude, as it is sometimes called), which may result in a possible frequent change of view; (2) the power of steadfastly maintaining one's position. From which do you think arise more errors in reasoning? Justify your answer.

13. A child thought for some years when she heard the song "Auld Lang Syne" that two lines ran thus:

> We'll take a cup of cotchinet
> For the days of auld lang syne

instead of

> We'll take a cup of kindness yet
> For the days of auld lang syne,

interpreting "cotchinet" to be a kind of wine. Give probable rational steps involved.

14. A small boy who had become much interested in fairies and the various transformations he had heard of in fairy stories was told that if he would pull apart a wishbone with someone and retain the larger part, any wish he might make would come true. At the next chicken dinner he got the wishbone, but was observed to hesitate considerably before he would pull it. Finally, very timidly, he did break it with his father and held the desired part in his hand. A look of intense disappointment came over his face. "Why, it's not a fairy, just an old bone," he remarked with disgust. What was the child's reasoning?

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CHAPTER XI

AFFECTIVE REACTIONS: FEELINGS AND EMOTIONS

1. Stimuli do something more than arouse sensation; they give rise to processes of a different kind, to feelings in a special sense; we do not merely take the impressions as they come, but we are affected by them, we feel them; and what we feel is their agreeableness or disagreeableness, their pleasantness or unpleasantness. . . . The writer holds that there is an elementary affective process, a feeling element, which is . . . coördinate with sensation and distinguishable from it but which is nevertheless akin to sensation and is derived from the same source. . . . This elementary process is termed affection. — E. B. TITCHENER, *A Text-book of Psychology*, p. 226

2. Affection is a simple mental process that is purely subjective, gives us no information of the outside world, and has for its distinguishing characteristic pleasure or pain. — N. A. HARVEY, *The Feelings of Man*, p. 12

3. The agreeable-disagreeable elements or phase of our states of consciousness is often spoken of as "affection," the total complex state in which it occurs being then called "feeling." This seems a convenient usage even if somewhat arbitrary, and we shall therefore adopt it. — J. R. ANGELL, *Psychology*, p. 258

4. We now come to a different kind of experience — experiences which are made up chiefly of systemic sensations or in which systemic sensations are of our bodily organism — not with events in the surrounding world. They are called *affective experiences*, and include the following sorts: *feeling, emotions, sentiments*. — H. C. WARREN, *Elements of Human Psychology*, p. 203

5. My theory . . . is that the bodily changes follow directly the perception of the exciting fact, and that our feelings of the same changes as they occur *is* the emotion. — WILLIAM JAMES, *Psychology*, Vol. II, p. 449

6. We acquire tendencies to respond with pleasure to stimulus patterns not originally pleasurable: and we lose the pleasure response to other patterns which originally released that response. The same is true of all the feelings, simple and complex. In the total mass of feeling-response . . . there is very little that is really "instinctive": the original tendencies have been so recombined and modified by learning that the resultant reaction-patterns are as thoroughly "acquired" as any group of reaction-patterns in the organism. — KNIGHT DUNLAP, *Elements of Scientific Psychology*, pp. 337–338

Topical Outline

The Nature of Affective Reactions
- *A.* As an aspect of consciousness
  - I. Personal reference: self-awareness (diffusive and monopolistic)
  - II. Properties
    - 1. Quality
      - *a.* Pleasant
      - *b.* Unpleasant
    - 2. Intensity
    - 3. Suddenly initiated and gradually terminated
- *B.* As to bodily changes
  - I. Implicit reactions
    - 1. Glandular
      - *a.* Internal
      - *b.* External
    - 2. Vascular
      - *a.* Circulatory changes
      - *b.* Respiratory changes
    - 3. Muscular (unstriped muscles)
  - II. Explicit reactions
    - 1. Glandular and vascular: paling, blushing, perspiring
    - 2. Striped muscles

Affective Reactions compared with Cognitive and Conative Processes
- *A.* Affection: sensation, perception
- *B.* Affection and thinking
  - I. Facilitating and inhibiting
  - II. Controlling and directing
- *C.* Affection and conation
  - I. Relation to inherited mechanisms
    - 1. Feelings and instinct mechanisms
    - 2. Primary desires
  - II. Relation to acquired mechanisms
    - 1. Attitudes, emotions, and dispositions
    - 2. Affections, habits, and skillful responses
    - 3. Sentiment

Methods for studying Affections
- *A.* Genetic method
- *B.* Questionary methods
  - I. General topical questions, arranged in form of syllabus
  - II. Methods requiring judgment reactions to questions
    - 1. Personal inventory: questions on self-feelings
    - 2. Objective stimuli
      - *a.* Form
      - *b.* Rhythms and melodies
      - *c.* Color and color compositions
- *C.* Graphic methods
  - I. Graphs of physiological responses: registered by tracing devices
  - II. Psychogalvanic reactions: registered by photographs

D. Association methods
- I. Without apparatus
- II. With apparatus

Theories of the Causes of Affective Reactions

A. Central theories
- I. Facilitating and inhibiting purposes
- II. Physiological theory: conscious accompaniment of anabolic and katabolic changes

B. Peripheral theories
- I. Reflex or back lash theory: bodily changes that follow directly the perception of the exciting fact is the emotion
- II. Innate theory: conscious accompaniments of the responses of inherited mechanisms

INTRODUCTION

Perceptions, ideas, images, concepts, have definite and discrete modes of response with an objective reference, and because of this latter factor they have been termed cognitive, or knowing, reactions. But most often cognitive reactions are accompanied by pleasant or unpleasant affective tones or feelings involving more or less motor and glandular reactions and withal a subjective and personal reference. Because these experiences refer to the self, and seem so individual and private, they are termed inner or subjective reactions. The generic term for this inner life is affection and includes feelings, emotions, dispositions, and sentiments. Examples of feelings are anxiety, drowsiness, eagerness, fatigue, familiarity, irritation, laziness; examples of emotions are rage, fear, joy, jealousy, grief, disgust, horror; examples of kinds of dispositions are domineering, meek, sullen, romantic, distrustful, reserved, benevolent; examples of sentiments are honor, vanity, reverence, sublimity, beauty, revenge. For full descriptions and distinctions between these several groups of affections the student is referred to standard works listed in the bibliography at the end of the chapter (**20**, **26**, **27**, **29**). But there are a few characteristics common to all affective experience that should be noted here, and for this purpose the more common term, feeling, will be substituted for affection. (1) All feeling reactions manifest distinctive bodily changes of some sort: gestures, bodily poses, blushing, paling, altered

breathing and circulation, and a variety of glandular activities. (2) Feelings and emotions are suddenly initiated and tend to frustrate purposes and to check orderly movements. They occur in the "most serious situations or predicaments of life" (**4**: 295–302) and run a more or less temporal course, gradually subsiding with the restoration of reflection and of orderly habitual movements. (3) Feelings and emotions aroused by certain objects and critical situations may serve to repress inappropriate ideas and ineffectual movements, and in addition may produce rapid, vivid effective thinking and action. (4) Objects and situations that arouse feelings and emotions tend to develop permanent attitudes toward them and may lead to an attachment of values having social, or æsthetic, or hedonistic, or phobic significance.

Scientific psychology began, grew, and was established by the study of sense perception, images, attention, and other problems apart from feelings and emotions. But if there is to be a science of human control and guidance, both for the individual and for the group, it must be based largely upon the laws of attitudes, feelings, and emotions. Such laws, owing to the difficulties involved in experimenting on feelings, are for the most part yet to be discovered. But it should be observed that modern psychology has greatly improved its position for attacking the problems of feeling. Hitherto our ignorance of the connections between glandular secretions and emotions has been bliss. The researches of Cannon (**6**: 110–301) and others have removed much of the darkness from that field and have shown that a more complete study of emotions must reckon with the effect of glandular activity upon the nervous system and emotional behavior. The methods applicable to these studies may be grouped as follows:

1. **Genetic method.** This method promises much, and in the earlier days of child study some progress was made in our knowledge of feelings by critical and systematic observations of infants and children. These studies have within recent years been resumed under improved scientific technique, as shown by the studies on instincts and emotions of children and by the more pretentious works on the pre-school child (**3**: 235–254; **13**: 229–230, 355–397).

2. **Questionary method.** There are several varieties of this method: (1) The first to be fully justified by its results was the use of questionaries, so-called. The investigator arranged a number of questions into rubrics, which in turn were grouped into a developmental order bearing on a general problem. Two examples of such rubrics, soliciting answers on emotions of anger, will illustrate the nature and form of the method.

Rubric 4. Describe overt acts, striking (how: down, straight out, with fist or palm?), scratching, biting, kicking. At what part are blows or attacks aimed?

Rubric 6. Describe long delayed anger, the venting of secret grudges long nursed, and deliberately indulged (**14**: 528–529).

(2) The second class of questionary methods involves a judgment in making the response and is further subdivided, according to whether the response-judgment relates (*a*) to the emotional attitude of the individual making the judgment or (*b*) to the emotional effects aroused by different kinds of objective stimuli. Examples[1] of (*a*) are furnished by personal inventory studies, where an attempt is made to have the subject describe his emotional condition by answering questions or by checking one of several suggested answers. The following questions may serve as examples: Do you ever have the feeling that you are falling just before going to sleep? Do you feel bored a good deal of the time? Have you had a queer feeling as if you were not your old self (**19**: 128–141)? The study of feelings by method (*b*), sometimes called the method of paired comparisons, uses such material as lines, areal figures, colors, tones, humorous cartoons, etc. (see Experiment 105). The stimuli are presented to the subject two at a time and every member of the series is paired with every other member. Although the method is tedious and exacting in technique, the results fully justify its use.

3. **Graphic method.** The graphic method, or the method of expression, investigates the relation between bodily changes and processes (as breathing, pulse, volume of limb, glandular secretion, muscular action) and the accompanying feelings. The

[1] Professor R. S. Woodworth was the first to devise and use these personal inventory questions.

variety and complexity of apparatus used and the skill and technique required to do successful work place this method in advanced courses.

4. **Association method.** The association methods use verbal stimuli and rely chiefly on the facts of verbal responses in the interpretation of the subject's emotional status. The procedure and technique have been developed for the purpose of studying pathological cases so that, except for purposes of illustration, the methods are rarely used to study feelings of normal persons. This is no reason, however, why association methods should not be used to study normal emotional reactions in usual laboratory courses. There is still need for simplification of procedure and for establishing norms in the interpretation of results before this method can be profitably used in academic work. As an aid in practice work the Association Frequency Tables for adults by Kent and Rosanoff (**18**: 77–125) and those for children by Woodrow and Lowell (**33**: 33–71) will be found useful. The lectures on the "Association Method" by C. J. Jung and certain exercises in Whipple's *Manual of Mental and Physical Tests* are instructive for laboratory exercises.

The method without apparatus consists in having the subject respond to a stimulus word by the first word or by a chain of words suggested by it. If a number of response words are required, it is well that only the instructor should know the required number. The value of response words as indices to emotional attitudes and complexes may be roughly determined by the use of frequency tables already derived and in use, by noting the points in the association where blockage occurs, and by using the subject's report (**31**: 177–179).

The association method is more often combined with the use of apparatus of one kind or another; chronoscopes, pneumographs, sphygmographs, plethysmographs, and the string galvanometer have all been drafted into the study of feelings in connection with the association method.

In approaching the study of emotions with the object of gaining a general view of the subject, it is well to do some special work on each of the following topics:

a. Make a list of the immediate causes of emotions.

b. Distinguish as to body location and as to function the receptors that give rise to feeling impulses and those that produce sensory impulses.

c. Observe that feelings are conscious experience — very much so — and that they have certain striking qualities.

d. Keep clear the distinction between the action of receptors that arouse emotions and the bodily reactions that express emotions.

e. Observe the temporal character of emotions with a view to detecting the order in which the several phases appear.

A careful record kept by the individual student according to such an outline will, in connection with the data available in texts and magazines, make for surprising progress in this problem, often so complex to the beginner in psychology.

EXPERIMENT 105. To study Feeling: the Response of Humor (Individual or Group Exercise)

Material. Ten humorous cartoons drawn by an artist of national repute (select cartoons of as nearly the same size as possible; mount them on cardboard of equal size and see that they are mounted smoothly); record blanks; exposure apparatus made by cutting two windows in cardboard, with a space of 2 in. between them, and of sufficient size to contain the mounted cartoons. Arrange lateral grooves along the lower edge and on the two sides of the windows cut in the cardboard. The cartoons for exposure may be dropped in the lateral grooves from above. The cardboard, about 22 in. by 28 in., is supported firmly in a vertical plane by means of uprights.

Procedure. *Comparison method.* By this method S compares every one of the ten cartoons with every other, the standard cartoon being placed first on one side and then on the other of the compared cartoon. The cartoons are numbered from 1 to 10. S should be seated comfortably before the exposure apparatus and in a room of uniform light. The standard cartoon is placed first on S's left and he is asked in each case of comparison if the standard cartoon is more or less humorous than the compared. If he says more, E places a plus sign in the row opposite the number of the standard cartoon and in the column below the compared cartoon (Fig. 46). If the judgment is less humorous, E enters a minus sign instead. As soon as

judgments have been made with each of the nine compared cartoons, the standard is placed on the right and the judgments are entered in a second table (Fig. 47). The judgments are always made with reference to the standard.

Results. *Subject's report.* This consists of the entries made in his two record blanks, samples of which are given in Fig. 46 and Fig. 47.

The right margin of each table shows the number of judgments in favor of each cartoon by adding the plus signs of the rows. The

	1	2	3	4	5	6	7	8	9	10	Total
1		+	+	+	−	+	−	+	+	−	6
2	−		−	−	+	−	+	−	−	−	2
3	−	−		−	−	+	−	−	−	−	1
4	+	+	+		+	+	−	−	+	+	7
5	−	+	−	−		+	−	−	−	−	2
6	−	−	−	−	−		−	−	−	−	0
7	+	−	+	+	+	+		+	+	−	7
8	−	+	+	−	+	+	−		+	+	6
9	+	+	−	−	+	+	−	+		+	6
10	+	+	+	+	+	+	+	+	+		9
Total	5	3	4	6	3	1	7	5	4	6	

FIG. 46. Comparative judgments of humor in cartoons. Series I, standard cartoon on left

totals at the bottom of each table show the number of judgments in favor of a given cartoon by adding the minus signs of the column.

To compute the number of judgments in favor of a given cartoon, find the sum of the *four* totals, one total of the row and one total of the column in each chart; for example, cartoon number 1 in Series I totaled 11 points and in Series II, 9 points, or 20 judgments in favor of its humor. The ten cartoons with their humor values may be arranged as follows:

Number of cartoon	1	2	3	4	5	6	7	8	9	10
Judgments in favor	20	14	15	21	16	9	20	16	23	26

Discussion of results. To what other material may this method be applied in the study of feelings? Since the table above shows

	1	2	3	4	5	6	7	8	9	10	Total
1		−	−	−	+	+	+	+	−	+	5
2	+		+	−	−	+	+	−	−	−	4
3	+	+		−	−	−	+	+	−	+	5
4	−	−	−		−	+	+	−	−	−	2
5	+	+	−	−		−	−	+	−	+	4
6	+	−	+	+	−		−	−	−	−	3
7	−	+	−	−	−	−		−	−	+	2
8	−	−	−	−	−	−	−		+	−	1
9	−	−	+	+	−	+	+	+		−	5
10	+	+	+	+	+	−	−	+	−		6
Total	4	5	5	6	7	5	4	4	8	5	

FIG. 47. Comparative judgments of humor in cartoons. Series II, standard cartoon on right

the comparative amount of humor in the several cartoons, how should you use these numbers to determine the sense of humor in the individual?

READINGS. **28**: 241–243; **35**: 156–158.

EXPERIMENT 106. To study the Value of Names of Emotions as an Aid to identifying Emotions expressed in Photographs

Material. Twenty photographs (face, arms, and upper portion of body visible); list of names of emotional states (see suggested list in the Appendix); record blanks.

Procedure. Divide the class into two groups. Members of Group I are required to write the name of the emotional state expressed in the picture after the instructor has read a list of names of emotions. S writes the numbers of the pictures in a vertical column and, after studying a picture with the view of determining the emotional state expressed by it, records the name of the emotion beside its number.

The members of Group II study the photographs *without* reference to any list of emotional terms and record the names of emotions as expressed by the photographs.

FIG. 48 (Part I). See page 312

FIG. 48 (Part II). See page 312

FIG. 48 (Part III). See page 312

FIG. 48 (Part IV)

Parts I, II, III, and IV are reproductions of twenty body-face expressions of common emotions. These are to be studied according to the directions and conditions governing the experiments of which they form the material

Results. The instructor or a small committee of students checks the results with the key given in the Appendix, and then computes the percentage of correct judgments. The individual percentages of the members of each group are written on the blackboard in tabular form, and the average percentage for each group is calculated.

Discussion of results. Do the results show that hearing names had a decided effect on subject's identifying emotions as expressed in pictures? Give an example from daily life of a similar instance where a prerehearsal of names increases the number of correct responses. Is it possible to make a correct response to one emotional expression of another person and yet be unable to describe the emotion? Do animals respond correctly to the emotional expressions of members of their own species? to members of different species? Why are bodily signs of emotions more readily identified than bodily signs of traits of character? Certain emotions expressed by the muscles about the mouth, as bitterness, disappointment, or vanity, are termed mimetic because they resemble the taste reactions, respectively, of bitter, sour, or sweet substances of considerable intensity. Explain how one and the same set of movements have come to express now an emotion, now a sensation.

Inference. Do the results justify a general statement; if so, what?

READING. 1: 228–231.

EXPERIMENT 107. **To study the Comparative Value of the Face, Arms, and Body in identifying Emotional States (Individual Experiment)**

Material. Twenty pictures, ten with body and face (numbered 2, 3, 4, 5, 8, 12, 13, 15, 19, and 20, in Fig. 48), and ten with face only (lettered *H*, *M*, *P*, *R*, *C*, *A*, *E*, *K*, *F*, *Q*, in Fig. 49); record blanks, each with a vertical column of numbers and another of letters.

Procedure. Divide the students into two groups. Let the members of Group I begin with the *numbered* pictures and write the name of the emotional state after the number corresponding to that of the picture. Having completed the numbered series, students of Group I now study the *lettered* series of pictures as above designated and write after each letter corresponding to the one on the picture the name of the emotion expressed by the picture. Students of Group II proceed in the same manner as those of Group I, except that they begin with the *lettered* series and finish with the *numbered* series.

Results. The two groups of students now turn in their records, duly filled out and labeled for both numbered and lettered series. The instructor or a committee of students checks the results with the key (Appendix).

Tabulate the percentage of correct identifications under headings "Face-Body" and "Face," respectively, and compute the average percentage for each series.

Discussion of results. What emotion was correctly identified most often? What one was most difficult, judged by the small number of correct answers? What conclusion may be drawn from the numerical results?

Inference. --

READING. 1: 224, 227.

EXPERIMENT 108. **To study the Classification of Emotions as expressed in Photographs (Individual Experiment)**

Material. Body-face pictures given in Fig. 48 and face pictures given in Fig. 49.

Procedure. 1. Study each of the twenty faces given in Fig. 49 with a view to classifying them according to resemblances in the expression of the emotions. Use the letter on the picture to identify the face and write the name of the emotion after the capital letter. The pictures thus arranged should form a series; for example, suppose your study of the pictures suggested a "determined" group, then the faces might be arranged so as to show a thoughtful face,

FIG. 49 (Part I). See page 317

FIG. 49 (Part II). See page 317

FIG. 49 (Part III). See page 317

FIG. 49 (Part IV)

Parts I, II, III, and IV are reproductions of twenty face expressions of common emotions. These are to be studied according to the directions and conditions governing the experiments of which they form the material

an earnest face, a resolute face, a challenging face. See how many such groups you can form from the twenty pictures.

2. Study each of the body-face pictures in Fig. 48 for the purpose of classifying them in groups similar to the plan just outlined.

3. From your study of the characteristics of each of the emotional groups more definite information has been secured for identifying, as well as for producing, emotional expressions. The present exercise requires a more critical and systematic examination of emotional expression in order to construct a synoptic table that will show the several changes which occur in the parts of the body-face in the more common emotions.

Results. After having formed groups from both series of pictures (body-face and face only) check your groups with those given in the Appendix. A form for a table is given here (Table XLVIII). The headings for the emotions are placed in a horizontal line and the body parts involved in the vertical column to the left. Before attempting to fill in the blanks of the table the student should study, in addition to the pictures of the text, the figures given in Darwin's *Expression of the Emotions in Man and Animals*, Tables I, II, III, IV, V, VI, and VII; Allport's *Social Psychology*, Figs. 22A and 22B; Feleky's "Expression of the Emotions," *Psychological Review*, Vol. XXXI (1914), pp. 33–41.

TABLE XLVIII. FORM FOR ARRANGING SYNOPSIS OF EXPRESSIONS OF EMOTION

	ANGER	CONTEMPT AND SNEER	DEFIANCE	FEAR	GRIEF	JOY
Brows and forehead						
Eyes						
Hands and arms						
Head						
Jaw (lower) . .						
Lips						
Mouth						
Nose						

The information derived from pictures and descriptions should by all means be checked and supplemented from the following sources: (1) children of all ages, (2) actors and actresses of the stage and screen.

Make a list of useful emotions.

Discussion of results. What value has the motto "Keep smiling"? In what group or groups of emotions do useless ones appear? May an emotional experience have a therapeutic value? Is there any physiological basis for the motto "Laugh and grow fat"? for the motto "Keep your courage up"?

Inference. What conclusion may be drawn from this experiment as to the value for purposes of classification of the two types of pictures.

EXPERIMENT 109. To study Anger

Material. A working outline as follows:

A. Grades of anger in order of ascending intensity are noted by numbers 1 to 5, 1 denoting the mildest, and 5 the strongest, anger feelings ever experienced by the individual

B. Degrees of irritability rated in the same manner from 1 to 5

C. Record for each case of anger

I. Self-rating for irritability

II. Day of the week; also, as far as possible, hour

III. Bodily condition

1. State of health before anger arose rated, as above, from 1 to 5
2. Organic state: tired, hungry, active, full of pep, etc.

IV. Mental condition before anger arose: normal, worried, anxious, excited, depressed, etc.

V. Cause of anger (stimulus) — describe facts briefly; no classification

VI. Reactions in anger

1. Gross bodily responses: speech, restlessness, all kinds of movements
2. Expressive movements: facial expression, clenching hands or teeth, tenseness of body, stamping foot, tears, flashing eyes, etc.
3. Activities of sympathetic system: heavy or rapid breathing, flushing, rapid heart beat, swallowing, nausea, trembling, etc.

VII. Impulses experienced but not yielded to: to answer back, to run away, to cry out, to knock someone down, etc.

VIII. Duration of anger in minutes (as nearly as possible)

IX. After-effects: irritation, sadness, worry, disgust, relief, tiredness

Procedure. At a regular meeting of the class in the laboratory the instructor gives to each student a mimeographed copy of the outline, with instructions to note carefully every case of his personal anger during the week, beginning with that day, and to describe it according to the outline as soon thereafter as possible. He is instructed to read within the first two days of the week, as an aid in filling out the outline intelligently, pages 84–98 and 203–209 of F. H. Allport's *Social Psychology*; pages 237–252 of Charles R. Darwin's *Expression of the Emotions in Man and Animals*; and pages 182–214 of Arthur I. Gates's *Elementary Psychology*, or some other chapter on affective reactions that is approved by the instructor. These readings, with material given in the lecture period, should form the basis for an intelligent record according to the outline given.

Each student is asked to note at the end of the week the correspondence between the rating he has given himself in irritability and the number of cases of anger he has recorded against himself.

Records should be made plainly and in outline form (a separate record for each case) and brought to class at the end of the week, presumably at the next laboratory meeting.

Results. General treatment. The instructor should obtain from the class data for the following:

1. A frequency table of the strongest and also of the mildest degree of anger (the table being placed upon the blackboard as soon as it is derived) and a frequency curve.

2. A frequency table and curve for the distribution of cases among days of the week.

3. A table showing bodily and mental conditions before anger, with frequencies.

4. A table showing causes, with frequencies, better expressed in percentage. The causes may now as nearly as possible be divided into two classes: (1) thwarting of some activity or desire, (2) thwarting of self-assertion. The latter may be divided into three groups: (*a*) a defensive action toward persons seems necessary; (*b*) an aggressive reaction toward persons seems necessary; (*c*) defensive reactions to things are aroused.

5. A table of response frequencies containing (1) gross bodily responses; (2) expressive movements; (3) activities of the sympathetic system.

6. A table of impulses experienced but not yielded to, with frequencies.

7. A table showing duration of anger in minutes, with frequencies.

8. A table of after-effects, with frequencies.

In all cases the frequencies of the degrees of anger are given.

These tables are put on the blackboard as they are derived and are copied by the class. They furnish the general material for discussion and conclusion.

Discussion of results. What degree of anger is of most frequent occurrence? How do the number of anger experiences vary with the day of the week? What are the most frequent causes of anger in the class? Which general cause appeared to be more important: thwarting of some activity or thwarting of self-assertion? Which degree of anger had the longest duration? the shortest duration? average duration? What kind of responses are most frequent? (Note individual differences here.) Were there any "soft answers"? How is anger shown to be connected with organic and mental states and functions? What kind of impulses are most frequent? Are these native or acquired? What kind (degree) of anger shows most impulses? What kind of after-effects are most frequent? Compare the various degrees of anger as to after-effects produced.

With what theory of the emotions do these results appear to agree best?

What is the effect upon the adrenal glands of strong anger, and what connection does this have with increased strength in such emotion? (See 6)

Give an argument from the standpoint of hygiene, based on results of this experiment, against strong emotional experiences.

Inference. Express your conclusions in a brief general statement as to nature, time of occurrence, and frequency of emotion studied.

READINGS. 1: 84–91; 6: 59, 76–79; 7: 237–252; 8: 312–329; 11: 182–214; 12[1]; 14: 516–591; 17: 442–468; 34: 119–136.

EXERCISES

1. Which sensations may most readily take on affective qualities: the organic sensations (pain, kinæsthetic sensations, etc., which inform us directly as to bodily conditions) or those which give us primarily knowledge of the outside world (hearing, sight, etc.)? Can you formulate a law of feeling from this?

2. Can you give any valid reasons for the idea that you can tell one's character from observation of one's face? Does observation of the body as a whole help in this?

3. Show how emotional experiences may be at the basis of an inferiority complex, illustrating by your observation or reading.

4. What support is given to the James-Lange theory of the emotions by studies of emotional expression? By calling to mind instances of strong emotion in yourself, would you vote for or against that theory?

5. Describe the appearance of an angry cat ready to attack an intruding dog.

6. Describe the appearance of two small boys thoroughly enraged, just on the point of a fight.

7. For further illustrations of strong rage, describe

(*a*) the appearance of a person you have seen enraged with respect to eyes, hands, nose, mouth, teeth, facial muscles, expression of face, breathing, general adjustment of body, shoulders;

(*b*) the feelings you have experienced yourself, when in a rage, in stomach and visceral organs, heart, excretory organs, etc.

8. Why may one lose control of one's judgment in strong emotion?

[1] This experiment has been adapted from Mrs. Gates's study through the courtesy of the Psychological Review Company.

9. The play spirit is the spirit of pleasure in an activity based on the activity itself. Discuss its importance for the lawyer; for the teacher; for the man of business.

10. Name some mental disorders that come from suppressed emotions.

11. How may the suppression of free speech be connected with affective reactions?

12. Why does rage sometimes bring an unusual strength (**11**: 188–191)?

13. Why does anger cause indigestion (**6**: 278–280; **11**: 204)?

14. Give examples of the following statements:

In *moderation* affective reactions

(*a*) are a tonic, give zest to life;

(*b*) aid in education;

(*c*) aid in the physiology of life, in the exercise of normal functions;

(*d*) are at the basis of the cultural values of æsthetics;

(*e*) by means of the play spirit, make easier and more effective every serious business of life.

15. If affective reactions were in excess in the five cases in the preceding question, what would be your statement in each case? Give an example illustrating each one.

16. The community drive to raise money for educational institutions, hospitals, and other worthy causes, in which a whole town is supposed to be interested, makes the widest possible use of psychological principles. When a large body of people are gathered together for coöperation in such cases, what are some of the activities calculated to promote and to continue pleasant affective reactions, such as interest, enthusiasm, etc.? Show how they culminate in the final day and the victory dinner.

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APPENDIX

EXPERIMENT 7 A

TABLE XLIX. CORRESPONDENCE BETWEEN $\frac{D.}{M.V._{D.}}$ VALUES AND CHANCES PER ONE HUNDRED

$\frac{D.}{M.V._{D.}}$	PER CENT OF CHANCES	$\frac{D.}{M.V._{D.}}$	PER CENT OF CHANCES
0.1	53	2.1	95
0.2	56	2.2	96
0.3	60	2.3	97
0.4	63	2.4	97
0.5	66	2.5	98
0.6	68	2.6	98
0.7	71	2.7	98
0.8	74	2.8	99
0.9	76	2.9	99
1.0	79	3.0	99
1.1	81	3.1	99
1.2	83	3.2	99
1.3	85	3.3	100
1.4	87	3.4	100
1.5	88	3.5	100
1.6	90	3.6	100
1.7	91	3.7	100
1.8	93	3.8	100
1.9	94	3.9	100
2.0	95	4.0	100

WORDS USED IN EXPERIMENT 45

SET I

1. resin, siren
2. Astor, roast
3. dealer, leader
4. peach, cheap
5. manor, Roman

SET II

1. night, thing
2. seating, teasing
3. smother, thermos
4. stoat, toast
5. dusty, study

INFERENCES TO FORMAL SYLLOGISMS IN EXPERIMENT 103

Series I

1. All *C* is *B*.
2. Some *C* is *B*.
3. All *A* is *C*.
4. Some *A* is not *C*.
5. No *C* is *A*.
6. Some *C* is *A*.
7. Some *C* is not *A*.
8. No *C* is *A*.
9. No *C* is *A*.
10. Some *C* is *A*.

Series II

1. A gopher has chisel teeth.
2. Some Yankees use trowels.
3. All turtles have protection.
4. Some blacksmiths are not aviators.
5. No woman is a member of the Boat Club.
6. Some good marksmen are members of the Boat Club.
7. Some chances are not taken by farmers.
8. No brokers are farmers.
9. No brokers are farmers.
10. Some lovers of nature are good observers.

ANSWERS TO EXPERIMENT 104 IN REASONING

1. 30.5 oz.
2. 9° Fahrenheit.
3. Forty-five trials.
4. Midway point.
5. *a.* Train A divides into two halves.

b. Engine A pulls first section of train A onto switch.

c. Train B, running on main track, passes first section of train A.

d. Engine A pulls first section of train A off switch onto the main track.

e. Engine B couples with second half of train A and backs train B over the switch until it has placed the second half of train A on the switch.

f. Engine B pulls train B past second half of train A.

g. Engine A backs the first section of train A and couples with second section of train A, etc.

ARRANGEMENT OF PHOTOGRAPHS EXPRESSING EMOTIONAL STATES IN EXPERIMENTS 106, 107, 108

Name of Group	Order of Pictures
I. Anger Group	*A* or 12. Contempt
	F or 19. Sneering
	K or 15. Defiance
	P or 4. Anger
II. Fear Group	*B* or 10. Amazement
	G or 9. Surprise
	L or 17. Horror
	Q or 20. Terror
III. Joy Group	*C* or 8. Knowing smile
	H or 2. Coquetting
	M or 3. Winning smile
	R or 5. Laughter
IV. Egoistic Group	*D* or 6. Haughtiness
	I or 7. Vanity
	N or 14. Pouting
	S or 11. Perplexity
V. Grief Group	*E* or 13. Serious thought
	J or 18. Pensive thought
	O or 1. Penitence
	T or 16. Grief

LIST OF WORDS NAMING EMOTIONS IN EXPERIMENT 106

joy	vanity	hate	surprise
delight	pouting	sourness	wonder
gladness	perplexity	ferocity	admiration
glee	disdain	grinning	timidity
happiness	scorn	grief	dismay
contempt	disgust	sorrow	anxiety
ecstasy	haughtiness	sadness	fright
cheerfulness	tenderness	despair	dread
rapture	anger	despondency	horror
pity	fury	pensiveness	terror
sneering	rage	penitence	determination
amusement	antipathy	humility	hesitation
laughter	repugnance	meekness	amazement
winning smile	defiance	serenity	agony

INDEX OF NAMES

GLOSSARY AND INDEX

glandular, and neuromuscular reactions.

Binocular vision, 177, 182. Normal visual response to the combined sense impression of both eyes.

Blind spot, 190, 192. An area on the retina, where the optic nerve enters the eyeball, void of rods and cones.

Brightness, 63, 87, 94. Sensations of light without color; achromatic light.

Catabolic changes. Destructive chemical changes in the body tissues.

Choice time, 28, 35. The duration between the presentation of one of several possible known stimuli and the making of a known response correlated with it.

Chronoscope, 36, 41, 149, 156. An apparatus for measuring time relations of psychophysical responses.

Ciliary muscles, 186. Two systems of muscle fibers connecting the choroid coat with the cornea.

Coefficient of reliability, 38. The ratio of the difference between the averages of two series to the mean variation of that difference, or the probable error of the difference.

Cognition, 28, 35. The experience of meaning arising from the external senses.

Color blindness, 90. A congenital defect in color vision, which results in the mistaking of certain hues for gray, and the inability to distinguish between certain other hues.

Complementary colors, 93. Two hues which when combined produce gray; in this case extremes of brightness (black and white) are complementary.

Conation. The volitional aspect of experience; desires, impulses, urges, often culminating in motor or glandular activity.

Concept, 281, 283. A generalized thought reaction having a meaning of universal reference aroused by a particular object or symbol.

Conditioned reflex, 131. An old response to a new stimulus, made by connecting the latter to a biologically adequate stimulus.

Confluxion, 193. Confusing something in the surroundings of an object with the object itself.

Consciousness, 15, 23, 25, 129. See **Awareness**. *Focal*, 104: the clearest portion of the conscious field at any moment. *Marginal*, 104: the less clear portions of the conscious field at any moment.

Constant error, 210. A tendency to err in a certain direction from the actual magnitude.

Contiguity. *Association*, 129, 140: the association of discrete objects that were experienced together or in immediate sequence.

Contrast. *Temperature*, 73: alteration in the intensity of warm or cold sensations due to adaptation to a different degree of temperature. *Visual*, 129: the effect of the visual after-image when projected upon a chromatic or an achromatic field.

Convergence, 178, 183, 186. The adjustment of the two eyes so that light rays from the same object fall upon corresponding points of the foveas.

Corresponding points, 179, 184. Geometrically similar points on the two retinas which would coincide if one retina were superimposed upon the other.

Cutaneous senses, 64. Those senses having receptors in the dermal layers.

same object into a single conscious reaction. *Tonal,* 85: the modified effect of two or more tones when sounded together.

Genetic method, 16, 303. A study of the origin and development of psychophysical responses as they appear in growing individuals.

Gland, 303, 304. One cell or a group of many cells which elaborate certain materials and then secrete the product for the use of the organism.

Gray, 87, 91, 94, 96. A sensation resulting from mixed light stimuli of all wave lengths in which no one length predominates.

Habit, 3, 10, 28, 132, 193. A more or less permanent connection formed between a receptor and an effector by practice and training. The permanent connection consists in decreased resistance in the system of neurones involved.

Hallucination, 162, 195. The mistaking of a centrally aroused image for a perception.

Hedonistic, 303. Relating to feeling.

Histogram, 148, 149. A graphic representation of a frequency distribution by means of a frequency surface divided into rectangles.

Idea, 29, 104, 133, 146. An image increased in meaning but with less pictorial content.

Illusion, 7, 162, 189, 197. A false perception; an error in interpreting peripheral impressions.

Image, 91, 129, 176, 180, 184. Centrally excited mental activity, usually representing a concrete object.

Imaginal type, 244. The predominant kind of sense reaction that forms the image, — auditory, visual, etc.

Imagination, 129, 243. The combining of images of different experiences into a new form of implicit reaction.

Implicit reactions, 3, 282. Conscious reactions centrally aroused by a substitute stimulus, the object of the reaction being absent.

Impulse. *Conscious,* 319: an energetic mental process pressing for expression. *Nervous,* 23, 24, 60: a special kind of physiological change propagated along a neurone, aroused by stimulation.

Inference, 284. A general statement of a meaning common to a number of facts; a perception of a relation between two judgments.

Inhibition, 25, 68. The blocking of a neural pathway so that the progress of the nerve impulse is checked; the shunting off of excitation to a motor neurone.

Innate, 46, 60, 128, 131. Belonging to the attribute of an organism (neural, motor, glandular, etc.), determined by properties resident in the germ cell from which it developed.

Integration, 14, 123, 282. The process whereby the central nervous system unifies and coördinates the separate systems and organs of the body into a unitary individual; functional integration stamps individuality upon all parts involved in a reaction.

Intelligence, 24, 203. "The capacity to do the right thing under given circumstances"; it consists in the appropriateness of reactions.

Introspection, 6. A systematic observation of one's conscious processes under standard conditions.

Irritability. The property of responding to stimuli; it is possessed by nervous tissue in the highest degree.

Judgment, 75, 284. A perception of a relation between two stimuli, either implicit or explicit, or one implicit and the other explicit; a thought process in which two concepts are combined.

Kinæsthesis, 26, 74, 243. Sensations aroused by the stimulation of receptors confined to muscles, tendons, and joint surfaces; it is fundamental to the perception of movement.

Knowledge, 62. Information and experience organized according to some purpose or theory; the orientive form of experience.

Learning, 201–237, 203. The process of modifying the individual's responding mechanism in the interest of new or more effective responses. *Types:* sensorimotor, as in learning to copy a figure; motor-skill, as in learning typewriting; association, as in learning dates and events; rational, as in learning to perceive implicit relations.

Local sign, 171. A supposed quality of tactual and visual sensations which serves to indicate what particular point on the retina or the skin is stimulated.

Localization, 72, 85, 171. The perception of the space position of a stimulus in relation to self.

Marginal consciousness, 61. Processes in any moment of consciousness having a minimum of vividness.

Masson disk, 144. A white cardboard disk having along one radius a succession of black lines of equal width and length; it is used to study fluctuation of attention.

Maze, 229, 230. An apparatus, rectangular or circular in form, consisting of an intricate pattern of runways (walled), including blind alleys, with only one runway leading to the goal, or exit; it is used to study the learning capacity of animals and of man.

Mean variation, 33, 38. Average of sum of differences between individual measures in a series and the average of the measures.

Mechanism, 3, 13, 23, 62. Neuromuscular or glandular organization that responds to peripheral or central stimulation.

Median. *Measure* or *score*, 32: that point in an array of measures on each side of which one half of the measures fall. *Plane*, 35: the plane that divides the body longitudinally into symmetrical halves.

Memorizing, 253–255, 272. The process of learning subject matter with a view to complete recall, either verbatim or as to meaning.

Memory, 132, 240–243, 245, 260–262. The recognition of a reinstated experience as one's own. *Primary:* the continuation of a conscious reaction after the stimulus has ceased. *Secondary:* the reproduced experience of which meantime we have not been conscious. *Span:* the number of discrete objects retained and expressed before or at the close of the primary memory period.

Method of minimal change, 63, 86. A psychophysical procedure determining the least difference that can be perceived between two given stimuli; both may be equal at the start and one changed gradually until a difference is apparent.

Mimetic movements. A group of responses made by lips, tongue, and face in an emotional reaction, which are similar to the responses made by the same muscles to special sense stimuli.

Mode. *Measure*, 32: The measure in a series of marks or scores that most frequently occurs. *In sensation*, 62: all sense reactions excited by the same type of receptor.

Monocular, 179, 182. Pertaining to all visual reactions made by the stimulation of one eye.

Motor attunement, 79. A neuromuscular condition or "set" due to repeated responses to the same stimulus to which the nervous discharges become graduated and at the same time ill-attuned to a stimulus of different intensity.

Movement, 21, 24. A coördinated action of many muscles working toward an end. *Voluntary*, 47–50. *Involuntary*, 51–54.

Nervous arc, 25. A chain of neurones that transmits a nerve impulse from a receptor to an effector.

Nervous system, 25. The integrated organization of the neurones whereby every part of the body is connected with every other part and made to function as a unitary whole.

Neuromuscular. Formed by an axon and a muscle functionally united in a muscle plate.

Nonsense syllables, 134, 256, 258. Words void of meaning, usually formed by a vowel with a consonant on each side.

Paradoxical cold sensation, 72. A sensation of cold aroused by the application of a hot stimulus to a cold receptor.

Perception, 160–200. A conscious reaction to a definite object or to a particular object present to the receptors.

Perceptual pattern, 162. An integrated system of neurones determining the perceptual response.

Perimeter, 88. An apparatus for studying the reactions of the periphery of the retina when stimulated by chromatic light.

Perseveration, 222, 239, 243. A tendency of an experience to return unbidden and momentarily to consciousness, sometimes with more or less regularity.

Personal equation, 22, 56. The error that occurs when an individual attempts exact measurements of any kind; it is peculiar to the individual and must be determined and allowed for whenever accurate results are desired.

Physiological. *Limit:* the point at which further learning or acquisition of skill ceases because of the incapacity of the neuromuscular system to respond any faster. *Zero*, 73: the temperature condition of a part or of the whole body to or from which no heat flows.

Plateau in learning, 227. A temporary check in the rate of learning.

Preperception, 166. The anticipation of a perception by means of an idea or image more or less like the object.

Pseudo-attributes, 61. Properties of certain sensations but not an integral part thereof; for example, after-image, contrasts, duration.

Psychophysical methods, 64, 205. Methods used to determine quantitative relations between stimulus and sensation.

Purkinje phenomena. An increase in the brightness of blue hues and a decrease in the brightness of red hues in twilight.

Rational, 280. Having the capacity to think and act in a purposeful and consistent manner.

Reaction pattern. An integrated system of neurones in the brain

centers producing characteristic responses.

Reaction time, 25. The time interval between stimulation and response.

Reasoning, 15, 280–299. Organizing and controlling previous experience in the interest of forming a plan of action or for solving a problem.

Recall, 245. A conscious reinstatement of images, ideas, or concrete experiences, or the reaction in which previous sense experience becomes conscious.

Receptor (sense organs), 14, 62, 205. Specialized cells at the peripheral end of a nervous arc having the capacity to change a particular kind of stimulus into a nerve impulse.

Recognition, 129, 240, 251. The identification of an image, object, or idea with the time, place, and circumstance in which the original experience occurred; or a response aroused by explicit or implicit stimuli and largely similar to the first response to the same stimuli and accompanied by a "feeling of familiarity," so called.

Reflex arc, 26. A nerve path or chain extending from a receptor to an effector and composed of sensory association and motor neurones.

Resistance, 76, 77. A sensation arising from the stimulation of joint and muscle receptors, spindle cells, so called.

Rote learning. Memorizing meaningless subject matter or material not understood by the learner.

Sensation, 60–99. An elementary conscious impression aroused by the stimulation of a receptor.

Sense experience, 163, 164. A conscious reaction to peripheral stimulation.

Sense mode, 62. All sense experience aroused by stimulating the same type of receptors, as taste mode, visual mode, etc.

Sensorimotor action, 205, 208. A stereotyped form of action following upon familiar sense stimuli.

Sensory circle, 69. A circumference on the dermal surface within which any two simultaneously stimulated points are perceived as one.

Sentiment, 302. A conceptual reaction accompanied with more or less feeling-tone; the reaction of an attitude to a situation or ideal.

Size-weight illusion (De Moor), 195. Of two objects unequal in size, but equal in weight, the smaller is judged the heavier.

Skill, 211. Habits and attitudes integrated into a mechanism capable of a more or less superior performance.

Sound cage, 174. An instrument for measuring the accuracy in the localization of sound.

Span of attention, 118, 121. The number of discrete objects one may attend to in a moment of time.

Stereoscope, 111. An apparatus by means of which two slightly unlike pictures seen by the two eyes are perceived as one and show depth.

Stimulus, 3, 23. Any force that excites a nerve impulse or current. *Pattern :* a number of unrelated or heterogeneous objects capable of being perceived as an organized whole.

Summation, 69, 85. The total influence of several stimuli producing a sensation that no one alone would produce.

Subordinate, 152. The relation of genus to species; for example, canine, hound.

Supraordinate, 155. The relation of species to genus; for example, trout, fish.

Sympathetic system. The middle division of the autonomic system.

Synapses, 131. The points of contact of axones and dendrites.

Systemic senses. Senses the receptors of which are located in the body and in the viscera; for example, hunger, nausea.

Tachistoscope, 115, 116, 135, 136, 143, 144. An instrument for making brief visual exposures, a fraction of a second or more.

Tactual space, 170. A spatial order developed from touch experience or sensation.

Threshold. *Of sensation,* 166, 181: the point at which, with increasing intensity of stimulation, a sensation is first perceived. *Of discrimination or difference:* the point at which, with increasing difference of intensity between two stimuli, their difference is first observable

Touch spots, 67. A term applied to touch receptors in the dermal surface.

Trait, 312. A differentiated structure or function sufficiently marked to be distinguished from other forms and functions; for example, structure, Hapsburg lip; function, grasping of infant.

Transfer in learning, 223, 227. The process whereby the skill or information acquired in a given field of learning favorably affects the rate of learning in a different field (subject matter).

Trial and error, 203. A method of learning marked by random and varied attempts in which chance successes are gradually selected (learned) and the unsuccessful efforts slowly eliminated.

Vernier, 42. A device, either a short sliding scale or a short pendulum adjustable to the graduated units of a larger scale of its kind, for measuring fractional parts of the units on the large space scale or time scale.

Visual field, 179. The area in space from which light rays are received into both retinas (larger than the horopter); that is, it includes the fields of both monocular and binocular vision.

Volar, 171. The palmar side of the hand, wrist, or forearm.

NOTE. A few words not used in the text are defined in the glossary, as they often occur in the assigned reading to experiments.

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